Early-stage Product Development in small technology-based start-up enterprises

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Kit Sidwell

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Abstract

Success in New Product Development can be elusive even to companies that are well financed, experienced in methodology, and in possession of a seemingly promising concept. In a small start-up business, often all the entrepreneur has to begin with is an exciting prospect, an idea for a product, but little in the way of direction and funding with which to make it a reality. Yet small companies in New Zealand and Australia are regularly attempting to enter markets with products that are often highly innovative and with great potential for growth.

With this in mind, research into early-stage product development in small, technology based start-up enterprises was undertaken, with the aim of exposing key management aspects that influence the path that is taken. The overall research problem for this study is therefore: *How do start-up enterprises undertake the early stages of technology-based Product Development?*

Several important areas of focus were established through a review of the literature, in order to target the research in a manner that could provide valuable theory building on the topic. The research questions addressed in this study are:

RQ 1: *What elements of NPD best practices can be adopted by start-up technology-based enterprises when developing new products?*

RQ 2: *What are the critical success factors and enablers for New Product Development in start-up technology-based enterprises?*

RQ 3: *What barriers to NPD are specific to Tech-start-up enterprises in New Zealand/Australia?*

A qualitative research framework was used to investigate these focus areas, carried out under a multiple case study methodology. The research questions and literature review guided development of exploratory interview questions, which were put to the director/ entrepreneur of 8 start-up companies in New Zealand and Australia.

The major themes observed were associated with addressing the needs of the market, collaboration, flexibility of the development process, as well as other management methodologies and tactics. This study concludes that early-stage product development in start-up technology based enterprises is an exercise in adaptive project management, in that each unique development requires a tailored approach in order to achieve the overall goal of a well-targeted product.

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1. Introduction

1.1 Background

Small businesses have an important effect on the success of an economy's technology sector, contributing significant numbers of new products that are developed and producing innovations at a proportionally greater rate than large companies. Being visible as highly valuable contributors to innovation (Carree & Thurik, 2003) for these reasons and others, small enterprises are therefore deserving of attention pertaining to improvement in innovation performance. This is especially true in countries such as New Zealand and Australia, where not only are a high percentage of enterprises small in size, the relative modesty of these companies compared to their overseas counterparts serves to accentuate their special influence. In fact, popular culture has New Zealanders portrayed as a country of innovators; individuals designing and building solutions to problems as they are needed, with minimal resources and prior formal training, is part of the national psyche.

However, with such an abundance of innovative activities must come an element of risk, the chance of failure that follows any undertaking or venture where new ground is broken. This is especially obvious in the high failure rate of new products developed by start-up enterprises, seen in the USA to be as much as 90% (Adams, 2010). With an apparent lack of such explicit statistics for New Zealand, one could purport that a similarly high incidence of failure could be seen – or at least, improvement on this figure would have to be dramatic in the extreme to bring it back to an unremarkable level.

New product failure can often be attributed to a number of causes, which can vary depending on the product, market, and the development path taken. Furthermore, there is also vast diversity in profile of the entities that attempt to develop these products – from the large multinational corporations to a single self-funded entrepreneur, intermediates of both such as university spin-outs and collaborative efforts, and resounding success can be achieved by all, and failure not exclusive to any. The large number of combinations of these conditions presents a spectrum of NPD contexts, yet the end goal of each is essentially the same.

When the issue is viewed in this manner, there is immediate doubt cast on the concept of one single product development methodology being appropriate for all projects. There is a strong argument for investigation into what the differences in context mean for the manner in which

NPD is carried out. This is reflected in the literature, with case studies being carried out across a variety of industries, probing different aspects of the product development process. However, while product development in New Zealand has gained some attention, it is either from a broad perspective or with patches of resolution as the focus is drawn in on more specific aspects of the local situation. There remains much scope for investigation into different entities and areas in the local industry, and also into different stages of the NPD process within this context.

In order to select an area upon which to focus this research project, it was important to single-out one that had good potential for derivation of value. With start-up enterprises commonly being more cash constrained than larger companies, it would seem appropriate to target an area of the NPD process that is less reliant on financial freedom. It is a well observed point that the early stages of product development are particularly influential in the direction that the project takes, and thus are critical to its eventual outcome. In addition, the beginning stages of development generally consume less of the overall budget than later phases such as engineering development. Small enterprises in New Zealand are seen to direct more of their total expenditure towards R&D than larger companies (StatisticsNZ, 2011a), making activities that better target or reduce the cost of R&D efforts of paramount importance.

The proportion of high-growth enterprises in New Zealand declined between 2004 and 2009, despite the entry rate of new businesses to the economy being high in OECD rankings (MED, 2011, p. 50). Larger companies themselves were once start-ups and may have taken a considerable period of time to establish themselves to the stage where cash constraints are less critical, and clearly this is not being achieved in many instances. Therefore any assistance that can be given to start-up firms to allow them to attain a more stable situation is seen as positive.

With this background in mind, the topic of this research project begins to take shape.

1.2 Research Problem and Research Questions

This study addresses the overall research problem:

How do start-up enterprises undertake the early stages of technology-based Product Development?

The literature contains many methodologies for New Product Development in a wide variety of company sizes, profiles and industry sectors, and is discussed in Section 2. Due to the diversity

of sources from which these methodologies originate, not all practices are relevant to or appropriate for all companies. Small technology start-up companies may not be realising the same benefit from traditional NPD processes as their larger or more established counterparts, and even those elements which are productive may not be viable due to tighter constraints on resources. Comparison with existing NPD methodologies could serve to clarify where product development in technology start-ups follows traditional or established practice, and where and why it deviates. There is the opportunity to identify aspects that are useful to start-ups specifically, and whether they are within reach of such entities. Where there are elements of the NPD process that are not viable, there may be alternatives that achieve the same end. In addition to this, technology based start-ups in the New Zealand context may employ entirely new methods to supplement their unique development needs.

In order to describe this broad research problem, three specific areas of focus were chosen. The first research question seeks to identify the situation that is manifested in start-up enterprises:

RQ 1: *What elements of NPD best practices can be adopted by start-up technology-based enterprises when developing new products?*

However, adoption of all available NPD techniques may not be possible, desirable or even effective in every situation. Therefore, investigation of factors that are critical to successful product development may provide clarity which could be used to better select the elements of NPD that are adopted. The second research question is then:

RQ 2: *What are the critical success factors and enablers for New Product Development in start-up technology-based enterprises?*

When implementing product development techniques with reference to critical success factors, there will be circumstances that enable or inhibit their ideal execution. The focus is on New Zealand/Australia based Tech-NPD Start-ups, and the third research question becomes:

RQ 3: *What barriers to NPD are specific to Tech-start-up enterprises in New Zealand/Australia?*

This is not to be interpreted as an attempt to highlight the areas that start-ups in New Zealand and Australia differ from the rest of the world; to achieve that goal, investigation of entities from other countries would have to be performed and comparison made. The scope of this project does not extend to that, thus it must be understood that the research question is

worded as such to explicitly show that the findings are exploratory within the New Zealand/Australia context only. This is due to the investigation being carried out within this geography only, and in no way are they asserted as factors that will be observed outside this niche.

With the overall research topic and specific research questions outlined, justification for the selection of these topics is now offered.

1.3 Justification and Contribution of the Research

In order for research to contribute to a body of knowledge, it must either present new information or reinforce existing knowledge about a particular subject. This study can be justified by its contribution to the extant literature regarding product development in start-up technology based enterprises, particularly in the context of micro and entrepreneurial entities in New Zealand. A distinct lack of research performed in this specific area is apparent, and there is also little that draws any comparison or connection with established product development theory. Most of the existing literature that touches on the topic is based on data sourced from studies generally performed in the USA, and from companies of much larger size.

The early stages of the NPD process are seen to have a disproportionately large influence over the whole innovation process, as major considerations such as quality, cost and timings are "mostly defined during the front end" (Verworn & Herstatt, 1999, p. 3). In addition, the cost of changes at this stage is lower than later when the project is more entrenched in its direction. Thus it is clear that the front-end is of interest to those seeking to improve their NPD performance, but also to do so in as cost-effective manner as possible.

Further justification can be found in the significance of small enterprises in New Zealand, and their large contribution to the innovation performance of the local industry. As recognised by the New Zealand Ministry of Economic Development (in their document MED (2011, p. 12), innovation "is at the heart of aggregate productivity growth, and entrepreneurship drives Innovation", and small businesses in New Zealand undertake more R&D than most of their OECD counterparts. Small enterprises make up a significant proportion of the businesses operating in New Zealand with over 90% having 9 or fewer employees (StatisticsNZ, 2011b), and overall 20% of all working New Zealanders are employed by these same companies (MED, 2011 Fig 3.1). Companies engaged in engineering product development can be found across the many different industries that these companies and employees participate in, particularly the manufacturing industry which contributes the greatest amount (13%) to GDP (Gross

Domestic Product) (StatisticsNZ, 2011a). Therefore these research findings are seen to be topical and relevant to a large community.

Compounding the implications of these demographic statistics are the high rates of new product failure and greater pressures to shorten development times. The consequences of product failure are likely to result in the failure of the start-up business as well. There is therefore a small but significant proportion of businesses undertaking valuable development work, and doing so under difficult conditions with a low statistical success rate. An academic contribution to the body of knowledge describing this context will serve to improve understanding of the issue. A greater understanding of the challenges faced and techniques utilised by enterprises in the early stages of their development projects can help to promote improvements in innovation performance.

1.4 Research Methodology Overview

This study conducted research into the early stage product development activities of small technology-based start-up enterprises. The research was based around qualitative in-depth case study methodology, in order to record the activities of such entities and address the research problem introduced in Section 1.2. A Multiple Case Study design was used, with the intention of performing exploratory and descriptive research. The “start-up enterprise” was chosen as the unit of analysis (Yin, 2009), as this is the entity that the project seeks to discuss (Patton, 1987) and build theory about.

The guidance of Eisenhardt (1989, p. 536) was taken into consideration, in that “theory-building research is begun as close as possible to the ideal of no theory under consideration and no hypotheses to test”. In practical terms this means that a picture of the current theoretical situation is formed through reference to the extant literature and questions are posed about areas that were lacking, but propositions and suppositions were avoided at the outset. This is to address concerns of bias emanating from pre-ordained theory.

Several stages were undertaken for the research, with background theory and data collection phases followed by the analysis and discussion.

The initial phase of the research project saw a review of the literature surrounding the broader topic undertaken to begin initial identification of the research area (see Section 2). Through this investigation key areas of interest were uncovered that were seen to be of particular

value, and the overall research problem was established. These key areas were then used to formulate research questions to focus attention on the research problem (see Section 2.6).

The second phase of the research was involved with data collection. In order to gather data in accordance with recognised scientific rigour, investigation into research methods was performed, resulting in the selection of an appropriate case study structure (see Section 3.2), and determination of appropriate respondents (see Section 3.3). A set of interview questions (see Appendix) were developed, which were put to respondents (see Section 3.4) with the intention of eliciting data on the current state of the phenomenon.

The final phase of the research project was concerned with analysis of the data that was collected, and interpretation of the findings. The cases are presented (see Section 4.5) to give context to the data that is then analysed. Finally, conclusions were drawn with reference back to the initial research questions and problem (see Section 5.5), discussion of the implications of the research (see Section 5.6), the extent to which findings of this research project are asserted (see Section 5.7), and where further investigation could be directed (see Section 5.8).

1.5 Definitions and Delimitations of Scope

This thesis discusses entities and concepts that may have different meanings in some contexts. Therefore it is necessary to clearly state what is meant by these terms, to avoid misinterpretation or confusion over the findings contained herein. Definitions serve to encapsulate the research and establish its scope.

Product Development. This research is undertaken within the field of engineering, and thus products that are developed are based in technology. The product need not be a physical object, as engineering technology is now inextricably linked to computers, with software programming elements often being part of a new design, or indeed forming the entire product itself. As this study has its focus directed more at the front-end of the product development process (see following definition), the bulk of considerations deal with the theoretical or managerial aspects of the design process. This is opposed to the later stages where a physical product would have very different manufacturing and distribution considerations than a software product, for example. The early stages of any product development project have greater commonality across different product types.

Early-stage Product Development. A product development project can be a complex process with many distinct phases, often iterative or circular, or many activities occurring concurrently,

or even an unstructured blend of reactive actions. To single out specific activities as being "early stage" would be to impose pre-conceived structure onto a project, and restrict the expression of alternative methodologies. Some activities may also persist through the project and have value at later stages as well. Furthermore, a specific time period constituting early-stage is not imposed, as projects work on vastly differing time scales and activities can be more heavily weighted towards either end of the development period. Therefore Early-Stage Product Development is a loose definition to encompass activities that enterprises undertake around the beginning of their product development journey. There is the concept of "the fuzzy front end", defined by PDMA (2011) as " Preceding the more formal product development process, it generally consists of three tasks: strategic planning, concept generation, and, especially, pre-technical evaluation" which are in general not excluded from the scope of this study. However, once again no specific activities are preconceived as being mandatory, so as to allow freedom of alternative expression.

There is of course an event that always going to come at the beginning, the initial concept generation or 'flash of brilliance' that truly begins the journey. For the purposes of this research, the sources or techniques behind the generation of the initial concept are not explicitly addressed, although worthy subjects and the focus of many other works. Rather, the management of the ensuing product development process is considered. Subsequent concept generation phases are downstream from this seminal point, and are therefore included.

New products and *Innovations.* A product can be distinguished as "new" by first observing definitions of *Incremental Improvements.* Schoenmakers and Duysters (2010, p. 1051) describe incremental inventions or innovations as those that "consist of minor improvements or plain adjustments to existing products or technology", and Nieto and Santamaría (2007) refer to the degree of novelty as being the important distinguishing factor. These statements could be interpreted as implying that major improvements and novel adjustments to a product qualify it as new, even it is in fact related in some way to an existing product. The occurrence of truly radical or "pioneering innovations" (Li & Vanhaverbeke, 2009, p. 844) is assuredly lower than those that contain some repeated elements of a previous design, therefore it was deemed unlikely that sufficient data would be readily collectable in the population that this study investigates. Rather, it was elected that a more relaxed definition be adopted, allowing products to be included that display a highly novel design, regardless of whether a product with similar intentions precedes.

Small Start-up Enterprises. Much as Small to Medium Enterprises (SMEs) have a different size division depending on the economy in which they are observed, small start-up enterprises are also seen to be varied in scale. Where a well-financed start-up may be able to employ perhaps dozens of people from the outset, this study is limited to the commonly occurring situation in New Zealand and Australia where an individual or up to 3 partners are involved. Larger numbers of employees or business partners would take the phenomenon being observed into a context upon which larger amounts of research has already been focussed, and is of lesser interest. Particular relevance is found in cases where development capital is limited or at least modest compared with the budgets wielded by larger established firms.

1.6 Outline of thesis

The structure of this thesis is based on the recommendations of Perry (1998b), with adaptions made to suit this case. Stylistic considerations and direction of content were made with reference to Beven (2007).

This thesis consists of 5 sections which are written with the intention of leading the reader through the research study in a structured and informative manner.

Section 1 introduces the overall topic of study, and provides initial discussion of the origins and impetus behind the research. Three research questions are proposed, to frame the intentions of the researcher and formalise the direction of investigation, and a brief discussion of how this is to be achieved is entered into. Further clarification of where this study fits into the current body of knowledge is achieved by pertinent definitions and outlining the delimitations of scope.

Section 2 is a presentation of the extant literature surrounding the area of research, both in its focal region and parent topic. Commentary on the accuracy of past research is largely avoided as the case study methodology employed is concerned with "inductive, theory building rather than theory testing" (Perry, 1998a). However, where necessary there is identification of conflicting theories and note is made of specific topics and contexts that have meagre coverage.

Section 3 explains the methodology that was used to conduct the data gathering phase of the research project. It begins by explaining exploratory and descriptive case studies and why they are appropriate for application in this instance, but also the limitations either inherent or imposed. The activities that were undertaken as part of this methodology are explained and

justified with Selection of Cases, Interviewing Technique and Data Collection procedures being the major points of discussion.

Section 4 presents the data, and then reports on the analysis of data that was collected in Section 3, and delivers the main results of the research project. A basic description of the cases that were observed is offered, to give context to the results whilst retaining confidentiality. Then, data collected from the interviews is reported, ordered and analysed. The data is compared to the theory that was gathered in Section 2, and is structured around the research questions that were proposed in Section 1.

Section 5 summarises the findings of Section 4 into discrete themes and conclusions, to display the results in a more concise, ordered manner. These conclusions are related directly to their corresponding research question. The implications these findings have on current theory and practice are discussed, however this study seeks to describe methodologies that are of value in current practice, rather than "developing normative description models" (Perry, 1998a, p. 787). Limitations are identified that became apparent during the course of the research project. Finally, areas of further research are proposed, and it is these avenues of study that could be used to test the theories that are introduced in this study.

1.7 Summary

This section has served the purpose of introducing the topic of investigation, through outlining a research problem and associated research questions. Justification for research into this area has been put forward, by identifying how it will contribute to the current body of knowledge. The limits of the focus area have been described, along with definitions of key elements that are referred to in this study.

The thesis sections have been introduced and a brief description of the content of each has been offered.

With the framework of the research area presented in this chapter, the next section of this thesis will cover current theoretical knowledge of the issues upon which this research project builds.

2. Research Issues

2.1 Introduction

This section reviews literature relating to the field of discipline, in order to provide a base on which the research project can build or reinforce. As described by Phillips and Pugh (2011), material is covered on both the focus theories and background/parent theories also. This will enable the study to test the focal area of research with theories sourced from throughout the relevant extant literature. This literature review will expose the research topic and justify the selection of the research questions introduced in section 1.2.

Literature pertaining directly to start-up enterprises is lacking in the area of product development, which provides much of the impetus behind this research project. The nearest relative to the start-up enterprise is the SME, an entity on its own, but also a natural progression as the business begins to grow. Greater research has been focussed on SME product development processes; therefore the major volume of discussion here is dedicated to this.

It is not the intention that the research problem be solved through conducting this investigation of the literature, merely that areas of the body of knowledge be identified that are either lacking in resolution, or are worthy of reinforcement or reiteration within a refined field of scope.

2.2 Literature Summary

Offered below is a table summarising the key contributing literature works referred to in this study.

Study	Main Issue	Industry/ Firm Size	Country Focus	Relevant Key Findings, Recommendations	Limitations
Davenport (2005)	Geographic proximity and organisational proximity of SMEs to similar firms and research centres. Effect on knowledge acquisition processes.	Manufacturing and Service SMEs	New Zealand	NZ firms able to grow and be successful internationally without reliance on localised knowledge sources. Alternative growth paths may be as viable as paths that progress through geographical proximity to other intra-sectoral firms. Absence of substantial domestic market/other local firms propels businesses into rapid internationalisation – therefore knowledge	Does not indicate whether presence of local intra-sectoral firms would result in local knowledge acquisitio

				acquisition activities become international rather than local, inter-sectoral or intra-sectoral.	n activities.
Davenport (1999)	Collaborative research projects between SMEs and Research Institutes, issues affecting success, and the development of trust to promote ongoing productive collaboration.	General R&D SMEs	New Zealand	Emphasis on establishing contractual trust and validating competence trust at the outset of the relationship. Intermediary organisations should primarily be viewed as providing an environment conducive to the development of trust. Repeat relationships are more likely under these circumstances. Policy should aim to support longer term collaborative relationships through providing a many faceted platform to facilitate the development of enduring goodwill trust.	
Senad (2006)	Dynamics of strategic alliances between SMEs and large organisations	Various SMEs	New Zealand	Strategic partnerships between SMEs and corporates require the establishment and maintenance of character-based trust, respect and interaction, establishment of personal ties at the management level. Resulting character-based trust and reduced relational risk contribute to alliance durability. On an organisational level, strategic alliances between SMEs and large organisations require systems and structures that facilitate collaboration. Establishment and execution of clearly defined goals and performance measures. Systems that facilitate the dissemination of information, and understanding of the alliance purpose and the differential operating realities between the partners.	Interrelationship and interactions between key elements (such as trust, personal ties and risk) are not investigated.

Schoenmakers and Duysters (2010)	Origins of radical inventions; knowledge types and sources that contribute to innovation	Various	Europe	Radical inventions based on existing knowledge and emerging tech, particularly in combination. Open Innovation may be an important contributor in radical product development, as mature tech/knowledge and emergent tech are given opportunity to combine. Open Innovation brings knowledge domains together that may not otherwise have been combined. Provides catalyst for radical innovation.	Technical origin of radical inventions only explains part of their emergence. Other factors not tested have effect, such as government, organisational characteristics, culture, and collaboration with universities.
Story, O'Malley, Hart, & Saker (2008)	The role of relationships and networks in the development of radical innovations.	Automotive, Manufacturing Various	United Kingdom	Loosely – defined relationships are required to precipitate the development of radical innovation in networks. Formality (contracts, procedures and role definition) are less evident. In radical innovation networks, trust development is a function of a clearly specified protocol for the technology development. In radical innovation networks, structures and stages for all parties are required to change as the development proceeds.	
Nieto and Santamaria (2007)	The importance of diverse collaborative networks in achieving novel product development.	Manufacturing Various	Spain	Technological collaboration, its continuity and the diversity of partners impact positively on product innovation. Diversity in the make-up of collaborative networks favours innovation novelty more than collaboration with a single type of partner. Suppliers are the single partners who most impact the achievement of novel product innovations, followed by clients then Research Organisations in order of importance. Collaborating with Research Organisations may be advantageous, but is	Desirable to have more complete information on the degree of novelty of the innovations. Negative effect of competitors on innovation results may be due to the

				infrequent and traditionally not viewed positively. Policy-makers could promote this type of collaboration. Collaborating with competitors has negative impact on novel innovation.	traditional profile of Spanish industry.
Mention (2011)	The influence of co-operation practices and the use of internal and external information sources on the propensity of firms to introduce new to the market innovations.	Service Various	Europe	Firms need to access and combine dispersed knowledge in order to achieve higher degrees of innovation novelty. Sourcing from competitors supports an imitation strategy rather than new to the market innovation. Policy-makers could stimulate firms to engage in public-private partnerships with research actors for their innovation activities targeting a high degree of innovation novelty.	Focuses on a single country and over a single time period. Subjective compone nt to questions.
Li and Vanhaverbe ke (2009)	The effect that inter-industry and country differences in firm – supplier relationships have on pioneering innovations.	Various	Canada	A positive effect of inter-industry difference is rather dominant. Large country differences have a negative effect on the likelihood of generating pioneering innovations, which implies that the learning and communication concerns may overwhelm the possible positive effect based on the technology specialization across nations.	Findings may not be able to be generalise d for firms in other countries.
van de Vrande, de Jong, Vanhaverbe ke, de Rochemont (2009)	Motives and challenges of implementing Open Innovation in SMEs. Incidence and trends.	High Tech Various	The Netherlan ds	SMEs are extensively practising Open Innovation, and increasingly so. Open innovation is as relevant for service firms as it is for manufacturing firms and research about open innovation should not be limited to those SMEs that have formal R&D activities. Medium-sized enterprises engage in and adopt open innovation more often than small enterprises and their adaption rate for all exploration activities grows faster. Open innovating companies tend to combine both technology exploration and exploitation, rather than focusing on one. SMEs make use of several open innovation practices at the same time to serve	Probably would get a more precise view on OI in SMEs with more narrowly defined OI practices. Survey data may not capture the full domain of external technolog y exploitati on and exploratio n. Start-

				customers effectively or to open up new markets, with higher-order objectives to secure revenues and to maintain growth.	ups and micro-enterprises (<10 employees) were excluded.
Dahlander and Gann (2010)	Definitions of Open Innovation, advantages and disadvantages of different forms.	Various	World	Four types of openness defined: Outbound Innovation (revealing or selling), Inbound Innovation (sourcing or acquiring). Implications for theory and practice are discussed.	
Bjerregaard (2010)	How conflicting and converging institutional logics of R&D work enable and constrain the process of R&D collaboration between SMEs and public university departments	Various SMEs	Denmark	Cultural differences between SMEs and Universities do not always negatively affect collaboration. In this instance, factors contributing to success were thought to be: - Individuals who had experience in both SMEs and Universities, thus understood both points of view - Some SMEs had undergone "scientification", and adopted academic norms Thus, "academic firms" complement "entrepreneurial universities".	
Broström and Lööf (2008)	The impact of firm's collaboration with universities on innovation. Whether academic knowledge has a positive impact on innovative sales and the propensity to apply for patents.	Manufacturing and Service industries Firms with 10+ employees	Sweden	Robust evidence is found that university collaboration positively influences innovation sales as well as the propensity to apply for patent for <u>manufacturing firms with 100 or [more] employees.</u> Service firms showed no significant success resulting from collaboration. Other size firms did not show results that were statistically significant.	Very low percentage of small firms engaged in collaborations.
D'Este and Patel (2007)	University – Industry linkages. Incidence of linkages. The different channels through which academic researchers interact with industry and the factors that influence the researchers' engagement in a variety of interactions	Various All sizes of firms	United Kingdom	Individual characteristics of researchers have a stronger impact on successful collaboration than the characteristics of their departments or universities. There is a higher level of interaction within engineering than other disciplines.	Study is focused on the role of researchers and universities, rather than companies.

Flores et al. (2009)	Universities as key enablers/facilitators to develop new collaborative environments for innovation. Benchmarking methodologies, critical success factors.	Various SMEs	Switzerland India	The four most critical factors are: Absorptive capacity, proximity, professors motivated to form collaborative environments, and entrepreneurship culture in the firms. Companies are actually the ones that can push innovations towards commercialisation and that is very much dependent on how open they are to learning and using the universities' knowledge.	
Fontana, Geuna and Matt (2006)	Factors affecting university–industry R&D projects. Firm characteristics that might explain propensity to undertake collaborative R&D Projects.	Various SMEs	Europe	Larger firms and those with intense R&D activities are much more likely to collaborate. Firms with small absorptive capacities had lower probabilities. SMEs that are open to the external environment, that search for external knowledge, screen/monitor the knowledge and signal their competencies are likely to collaborate. Differing levels of each of these activities influence the manner and success of the interaction.	
Goh and Thorpe (2008)	The main influencing factors that affect innovation and technology transfer in a University-Industry collaboration context	Various SMEs	Australia	The lack of time, capital and new technology knowledge are seen as hurdles for regional SMEs in innovation and technology transfer. Lack of strategy and organization mostly attributed to the working owner's personal attributes. Most individual SMEs would need some form of external advisory and mentoring support, and industry support. Government agencies have an important role to play, to be accessibility conduits, facilitators and pseudo-financiers. Universities can provide some of this support, though it is acknowledged that it may not be the best candidate to provide it without being given a government-based mandate to do so.	
Faems, Van Looy & Debackere (2005)	Inter-organisational collaborations, effect on innovation. Impact of different partners on innovation performance and type of innovations	Various Industries All sizes of firms	World	The more firms engage in a variety of different inter-organizational collaborations, the more likely they are to create new or improved products that are commercially successful.	

	generated.			Collaboration with different types of partners coincides with different types of innovation outcomes - collaborations with customers (exploitative) are associated positively with Incremental innovations, while collaborations with universities and research organizations (explorative) are associated with new products.	
Becker & Dietz (2004)	R&D cooperation and innovation activities of firms. Innovation input and output, and effect of number of partners.	Manufacturing All sizes of firms	Germany	Joint R&D enhances firms' R&D intensity. The number of cooperation partners affects the R&D commitment positively. Heterogeneous R&D cooperation releases synergies and enhances research productivity, and enhances the probability of developing new products. Likelihood of realizing product innovations rises with the number of parties involved.	Does not asses longitudinal effects, so efficiency over time has not been assessed.
Miotti & Sachwald (2003)	Examines the choice of partners with which firms co-operate on R&D.	Mainly Hi-tech All sizes of firms	World	The choice of partners is dictated by the complementary resources that the partnering companies possesses. The reasons that explain why firms co-operate simultaneously also determine with whom they co-operate.	
Braun & Hadwiger (2010)	Knowledge transfer from research to industry	Food Sector Mainly SMEs		The central obstacles that hamper the transfer of new scientific insights to SMEs are trust and language differences. Other hampering factors are: assumed benefits of possessing knowledge exclusively, lack of face-to-face contact with industry partners, culture differences, lack of structures for knowledge processing.	
Horowitz Gassol (2007)	Discusses the effects of university culture and structure on university-business relations, focusing on knowledge transfer activities	Various Industries Mainly SMEs	Venezuela	If links between university and business are introduced into the university system as a turn-key proposition rather than as developmental process, the prevailing university culture and structure will exert resistance against change and will oppose the creation of appropriate structures to promote them, with deleterious effects for the	

				university. Academic "freedom" may be threatened by the market focussed needs and accountability required by the industry partner. There is need for a system to balance between the "knowledge creation" (university) and "knowledge transfer" (industry) cultures.	
van Geenhuizen & Reyes Gonzales (2006)	Location near to clusters and its effect on innovation	Biotechnology All sizes of firms	Netherlands	Clusters do not have an effect of product innovation for small firms, young firms, and R&D type companies. Advantages from clusters can be derived, but only after a considerable establishment period, and when problems or stagnation occurs that motivates networking.	
Van Geenhuizen & Soetanto (2009)	The obstacles that academic spin-offs face at different ages	High Tech Start-ups	Netherlands	The overall ability to overcome obstacles decreases at age four –most probably due to "credibility juncture". Highly innovative spin-offs start with many obstacles but move relatively quickly to sustainable growth. Incubation centres are encouraged to better screen companies before fostering them, favouring highly innovative examples as these will be quicker to achieve sustainability.	Small sample size from only one university.
Blessing & Parker (2010)	Information needs of SMEs – the use of internet information resources in product development	SMEs	United Kingdom	SMEs have a large number of different information needs. Current search engines have shortcomings in answering these needs. Knowledge is difficult to capture – can be confidential or in a form not readily applicable. An intelligent intranet system to capture information may result in enhanced availability of information and therefore product development capability.	
Cooke and Buckley (2008)	Web 2.0, Social Networks and Market Research	All Industries All sizes of firms	World	Technology can assist in making large quantities of data available. Online social networks do not equally represent all types of people from the relevant population. Interaction in such networks can influence peoples responses away from what they would be in isolation.	

Corso et. al. (2001)	Information and communication technology (ICT) in product innovation	Manufacturing SMEs	Italy	Complexity at both product and system levels is a key driver of ICT. However, the directions of these effects are complex and dependant on the characteristics of the SME.	ICT is a rapidly improving field, results may lose validity quickly due to technologi cal advances
Ries (2011)	Entrepreneurs and continuous innovation	All sizes of firms	World	A book on how to create a more successful business, the entrepreneurial product development process	
Adams (2010)	Market Validation	All sizes of firms	World	Steps to test and validate a market opportunity. Bringing a concept to the market.	

2.3 Early-Stage NPD Process

The path that a company takes becomes narrower and narrower the closer they come to the launch of the product, and it can be clearly seen that the decisions made at the beginning influence on which path the company will travel. Freedom of movement is greatest at this early stage, and the cost of making changes will only increase from there on in. A large company with deep pockets may be able to buy themselves a direction change later in the project, and even survive going back to the drawing board after their product flops in the market. This is not an option for a low-budget start-up; the cost of change becomes prohibitive later in the development process, and failure of the product in the market certainly means failure of the company.

As described in Section 1.5, the early stages and the “front end” of product development are the activities that are undertaken by an innovating enterprise at the beginning of their project. The early phases of the product development process have the highest impact on the project and the result, due to the influence it will have on the design and costs that follow (Herstatt & Verworn, 2001). This is especially notable when viewed in terms of the minor contribution to the overall project cost that this major influence sequesters.

The early-stage management decisions that are made are therefore a key concern, and interest is taken in how these decisions are made. Griffin, Hoffman, Price, and Vojak (2007) describe the development process in start-up enterprises as finding the problem, understanding the problem from technical and customer perspectives, and the competitive

situation. The opportunity is then iteratively refined until a solution is found that enables movement into development. Davila, Foster, and Li (2009) suggest that more formal management control systems are used in entrepreneurial firms, and that enterprises select the appropriate tool adaptively based on the challenges they face. These observations are supported by Verworn and Herstatt (1999), who explain that learning based models are used when product or market uncertainty is high, as it is with innovative development. However, they propose that process models such as the ones investigated by Davila et al. (2009) are in fact associated more with incremental improvements. This is explicitly supported by Khurana and Rosenthal (1998); their case study suggested standardised approaches favour incremental developments, and that the company's approach must match their decision making model to the context of the product, market and organisation.

The early stage NPD process is well recognised as being un-structured, therefore there are many references to methods that help "Take the chaos out" (Griffin et al., 2007, p. 2). These methods themselves may be rigid, or they may be more general management approaches. Koen et al. (2003) describe many effective methods, tools and techniques for undertaking the early stage product development process. Top of their list is a collaborative culture, one that encourages innovation and creativity. Whilst they promote a creative approach to an unstructured process, they also press the point that consistency of purpose and aggressive goals be present. (Marion & Simpson, 2009) suggest that established product development processes can be utilised by new ventures, even when dealing with a vague development direction. No matter how fuzzy the front end, there is a way to set a course through it. Nobelius and Trygg (2002) are also proponents of a less rigid approach to front-end management, as the title of their article proclaims - "Stop chasing the Front End Process". In this work they warn against the likelihood that there will be a one-size-fits-all process for development. Instead they suggest managerial flexibility, most notably in project priorities and advance planning of development activities. They are not suggesting flying-blind, however. They recommend investigating several different strategies and screening them for the most appropriate one. Like Marion and Simpson (2009), they advocate having a definitive path through the project instead of simply copying the most common methodology. This seems to be a middle ground in the flexibility vs. rigidity debate, offering a compromise of sorts.

As described in Section 1.5, early stage activities are not restricted in this study to only those that are classically recognised as belonging at the beginning. Marion and Simpson (2009) refer to iterative development processes where early prototyping can occur, not necessarily only after conceptual design is fully finalised. Circling between the objectives of defining the

concept and building and refining models the manner in which companies should strive to find a solution according to Griffin et al. (2007). The iterative approach is referred to by others ((Koen et al., 2003; Nijssen & Lieshout, 1995; Verworn & Herstatt, 1999), thus blurring the stages of product development somewhat. The overall impression is one of a reluctance to leave the "front end" of the product development until entirely certain of the product being developed. Or another perspective that perhaps fits the iterative methodology is that the front end is brought through the project with the product, there is recurring reference to the principles which are were begun with.

2.4 Market Validation

Developing a product that many people want to buy is an obvious driver behind business activities. Sales are an essential factor in business success, and it is no great revelation that a desirable product is a key ingredient. Market Validation is directly associated with achieving this, however it is a different concept to common market research. Described by Adams (2010, p. 2), Market validation is "a series of common business practices assembled in a unique way that prove the validity of the market *before* you make the product investment".

Researching the market is a large part of finding out what need is present, but it is a far cry from actually establishing that a product opportunity is viable. "A Strong Market Orientation—Market-Driven, Customer-Focused" appears as one of the well-known critical success factors of Cooper (2003, p. 140). He advocates "a thorough understanding of customers' needs and wants, the competitive situation, and the nature of the market" and explains many of the factors that make up the market validation principle. Recognition of customer needs features prominently, but it is the details of "need satisfaction" through "constant customer contact" and "strong market knowledge" that are more directed towards validation of a market. The identification of a market need is an essential milestone and often a concept-inspiring moment, but it is also decidedly preliminary; the real function of market validation starts at this point and continues until a product and market are ideally matched.

Need satisfaction is the aim, and it is the attention to achieving this that is the main push. Market research discussions generally centre on finding a market opportunity or placing a product in the correct market, but few discuss performing both of these at the same time and also dynamically adjusting the concept around what is found. Ries (2011) explains a lengthy process of finding a point at where a product will settle, by investigating and revising all aspects of the problem and learning where changes are optimally made. An assumption that is

made is that changes mean additions or improvement of features. Often called “adding value”, the perspective of Ries (2011) is that activities like this actually reduce value, they represent waste in the sense that it is recognised in Lean Manufacturing principles. Instead, removing features actually adds value. This can be value to the customer, but also the enterprise. To the customer, the product has fewer features but those features are the important ones, and fewer features mean that the developing companies finite resources have been focussed on those alone, not spread over many. The result will be more complete in the ways that matter. Value to the enterprise is found in a simpler development project with narrower scope and more realistic goals.

Literature directly referring to Market Validation as a whole concept or methodology is scarce. It seems that whilst the business concepts involved are not new, grouping them into one framework of methodology is a relatively new phenomenon. What is interesting is its appropriateness for small resource constrained enterprises. A model which advocates reducing scale and rapid progression would enable or empower entrepreneurs somewhat.

2.5 Start-up Enterprises

The exhibited behaviour of small start-ups is, it appears, is driven mainly by necessity and scarcity of resources (Marion, Friar, & Simpson, 2012). When attempting to understand the reasons that small enterprises make the decisions they do, an evaluation of the most influential factors should be undertaken. This is always an integral part of evaluating any case, but may not be clear cut or simple in every instance. For example, if this logic were to be applied to a large business in order to shed light on why a certain reaction was initiated, a very large phenomenon such as an economic shift or governmental change may be required; lesser factors on their own may not exert sufficient influence. Here the motivating factor would be quickly identified, a clear root cause to which the company reacts. However, there is the instance where many smaller events may combine in a certain way that the result is influential, even with none of the factors being overly significant on their own. In this case it is more difficult to indicate a likely root cause with a broad, high-level evaluation. It can be seen that complexity of circumstance would play a role in convoluting the interaction of influences, as with every layer of detail there is more uncertainty introduced as to the underlying root cause. Perhaps small start-up engineering enterprises can be more easily understood, or their motivating circumstances more readily exposed than their large counterparts. Taking stock of the major defining features of these entities can yield some insight into what their major

influences are likely to be. Decisions that are made are then more easily put into perspective, proportion, and context.

The defining features are of course apparent in the name that has been chosen to identify these entities - Small, technology-based start-up enterprises. A constraint that many small businesses perceive but is not included in the name is lack of development money. Whilst it may be tempting to append with the words “bootstrapping” or “shoestring”, not all start-up enterprises are such– there are those that secure financial backing of considerable heft. However, these enterprises may use their money to hire staff, to bring in manpower that the cash-constrained entrepreneur cannot afford. Such firms then cease to be “small” under the definition that is used in this research project. Lack of funds is therefore more strongly associated with smaller firms but it is not taken to be a defining feature, merely one that afflicts many.

Being technology-based is a definite categorisation, however not one that is unique or particularly remarkable. The challenges faced by start-ups in a technological development project may well be different to those faced by other companies, but the science of the product is no different. This classification serves to give context, but does little to offer any great insight into why start-up enterprises act the way they do. Beven (2007) explains that being technology based refers to the level of technology in the end product, rather than the use of technology in designing or manufacturing. Furthermore, the level of complexity and engineering challenge in such products is quite considerable for new-to-the-world products. The immediate picture that comes to mind is that of a market leading corporation such as one of the electronics giants – complex high-budget developments taking place within a gleaming glass office structure. Thus it may be agreed upon that being a small start-up and undertaking high-level, high tech-tech projects is a departure from commonly envisioned sensibilities.

Being a start-up enterprise is one of the key attributes that can be seen to affect outlook and behaviour. There is the immediate implication that lesser experience is available to be leveraged. An entrepreneur may have vast experience in development, and core competencies in many valuable fields, but there is no denying that the innovative product that is being developed is an unknown quantity. There has never before existed a venture entirely the same as the one that is now being attempted, so it is impossible to be entirely experienced. This may seem to be arguing semantics, but when contrasted with an incremental improvement project on an established product by the founding company, the relative experience level becomes more apparent.

“Building a start-up is an exercise in institution building” (Ries, 2011). There is a not only a product concept to develop, there is an organisation to create, structure to form and organise.

2.6 Collaboration

There are practices that once were the bastion of only certain companies, ones that had the power and vision to effectively implement them, and these could provide a significant competitive edge. Research and Development for instance, being expensive in general, is obviously more financially comfortable when undertaken by a larger company that has the resources to do so (Goh & Thorpe, 2008). Historically it was a strategy of many highly innovative large companies to build strong internal R&D departments, staffing them with talented minds, providing extensive resources, and keeping their innovation activities secretive behind closed doors. Novel new products could be unleashed on the market, with lesser-resourced competitors struggling to match their innovation power. In recent years, however, this model is no longer seen to be as robust as it once was.

Whilst in general companies still endeavour to develop their internal capabilities as well as they can, there is a limit to the knowledge that can be practically contained within one company. The depth and breadth of technical knowledge spread throughout the world is such that attempting to effectively bridle it within the walls of one organisation becomes a futile endeavour. It is the realisation that this may not be required, that knowledge may be accessible and developable without exclusive in-house possession that underpins the concept of Open Innovation (OI).

Chesbrough (2003), credited with coining the phrase and seminal works on the subject, attributes the shift towards Open Innovation to factors such as skilled workers being more mobile throughout the world, venture capital sources expanding, greater availability of outsourcing partners, and recognition of the potential for capitalising on unused technologies and ideas. His discussions mainly focus on the phenomenon as it pertains to large enterprises – those that in the past would have been candidates for successful implementation of the old ‘Closed Innovation’ methodologies - and how they can make a successful shift to OI practises. Becker and Dietz (2004, p. 220) cite “the increasing dynamic of technical progress, the growing complexity of technology and the expanding stress of competition and costs” as factors underlining the necessity of R&D collaboration. Others enter into discussion about Open Innovation in Small-to-Medium Size Enterprises (SMEs), highlighting various advantages and disadvantages these businesses experience compared to the larger entities.

On balance it appears that Open Innovation is regarded positively for a variety of company demographics in general, but understandably the case-specific implementation, situation and environment a company is operating in yield a distribution of results. The increasing adoption of Open Innovation is shown in Fig. 1, especially popular with companies involved in high-tech innovation.

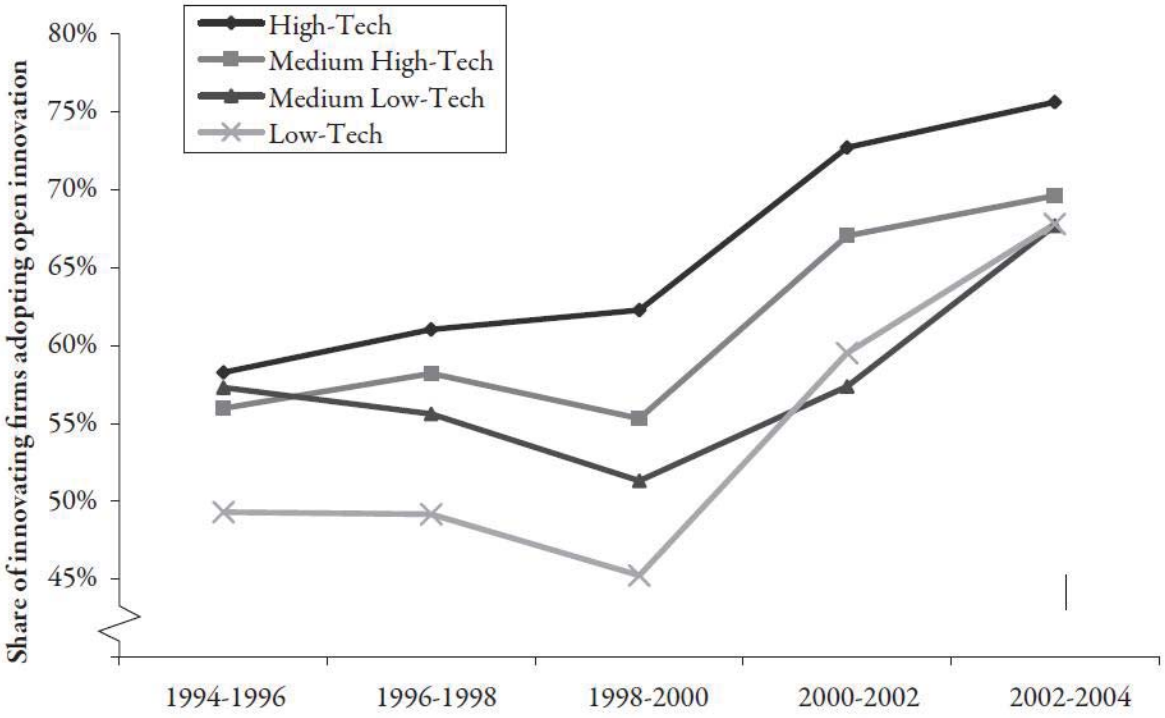

Figure 1 Source: Batterink (2009)

Batterink (2009) also observed a particularly notable rise in the adoption of Open Innovation strategies of SMEs in the Netherlands, but recognises that large, high tech firms are still the most inclined to adopt them. Within the unusual, possibly unique business environment of New Zealand it is difficult to predict with certainty what will result from Open Innovation practices, as the current body of academic research with this focus is rather thin in comparison to studies of OI in the SMEs of other countries. There are several notable works which make a significant contribution, but the subject is far from comprehensively covered, lacking the resolution required to recommend business strategy with high confidence.

2.6.1 Collaboration in SMEs

There are many dimensions that can be seen to contribute to OI, especially when following a broad description such as “Open Innovation processes combine internal and external ideas into architectures and systems” (Chesbrough, Vanhaverbeke, & West, 2006, p. 1). Strategic

Alliances, Collaborative Product Development, Knowledge Acquisition, Innovation Networks, Knowledge Networks, and Clusters are all broad areas that are of interest to SMEs and researchers that seek to improve product development performance, and indeed this is not an exhaustive list of the pertinent subjects. The size and complexity of each of these areas may also be considerable, and provide scope for much study individually. However, within a SME there may be many of these occurring at any one time, perhaps over several different projects, or all in pursuit of one. There is expectation that interaction between them also occurs, and when combined with case-specific considerations it is surely a complex phenomenon when viewed as a whole. It is felt that a holistic view of SME's Open Innovation activities is required to gain an appreciation of the true situation.

It is important to clarify what constitutes "collaboration" as there are many instances where companies utilise resources from outside their organisational boundaries. Outsourcing at once comes to mind, as at a low level it is a practice in the same vein as OI, being an external option that can greatly assist the product development process. Basic outsourcing is most often utilised for predictable supply of services, easy access to capabilities and competencies that are not available within the procuring company (Heap, n.d.). The benefits of this are well recognised as mentioned previously, but the effect on the level of product development *innovation* in the company is not as profound. True collaboration in an OI sense seeks to combine the knowledge of companies in order to increase the novelty of products generated or provide knowledge in order to find solutions. Outsourcing of design activities or R&D come closer, but the disconnect that is usually present is likely to restrict the multiplication factor that can occur when more than one party develop ideas together.

2.6.2 Collaboration and Innovation in Product Development

Innovation is well recognised as necessary for sustainable competitive advantage, therefore practises that promote it are clearly of interest to companies that are motivated to succeed. Anyone who has aired their ideas to a group of capable people will have experienced the succession of concept development that occurs, and may appreciate the speed at which leaps of advancement occur. Perspectives are offered that may otherwise have taken longer to become appraised of, or never even been realised. A brain-storming session is an excellent example: Quite apart from the skills of the individual collaborators, which are likely to be considerable when in a professional setting, it is the manner in which participants are able to grasp others ideas and advance them conceptually as their own impression leads them that drives the creative process. The manipulated ideas are passed back to their originator who

then may be able to achieve a conceptual leap that may have initially been distant. Of course this happens naturally within a company's internal design department, but the participants will be the same and therefore the potential for novelty is merely standard. Open the dialogue to other forums and a broader spectrum of knowledge is amassed, so that "cumulative learning" (Becker & Dietz, 2004) can occur, the fruits of which come with enhanced expectations.

Many researchers indicate that radical innovations are promoted by collaboration (Li & Vanhaverbeke, 2009; Mention, 2011; Nieto & Santamaría, 2007; Schmickl & Kieser, 2008; Schoenmakers & Duysters, 2010; Shinn, 2005; Story, O'Malley, Hart, & Saker, 2008), especially instances that marry diverse knowledge, and both mature and emergent technologies. Schoenmakers and Duysters (2010) suggest that combining knowledge domains which might not usually be connected increases the incidence of radical innovations especially. Nieto and Santamaría (2007) agree that diversity in collaborative networks favours innovation, both in degree of novelty and quantity of products generated, and assert that "different types of collaborative networks can be a critical success factor to achieve such innovation" (p375). This is similar to the views of Becker and Dietz (2004) who state that "The mix of heterogeneous parties in R&D cooperation releases synergies and enhances research productivity in a specific way" and that the probability of new products being developed increases through collaboration.

In addition, the value of collaborative product development is greater when applied to radical innovations than when applied to incremental innovations. Schmickl and Kieser (2008, p. 488) state that "knowledge transfer between specialists is more intensive in highly innovative than in less innovative projects", and explain that complexities in such projects invoke this. An incremental innovation is only a small extension to a knowledge domain within which a company is comfortable in working, so there is often less need to look beyond the company boundaries for the required information. When development of a product begins to break new ground, it is to be expected that the limits of knowledge contained within one company may rapidly be reached. This is not to say that the innovation cannot therefore be completed by the workers within that organisation, but that there is the obvious requirement for knowledge to be discovered, procured, imported, or otherwise developed so that the project can eventually succeed. Collaboration with other entities that possess the skills, technology or better means with which to develop these becomes an attractive option when a project begins to stretch the limits of a company's immediate capabilities.

A logical continuance of this line of thinking is that SMEs are clearly less likely to have the immediate internal capabilities required than a larger company would have, if attempting the same innovation. Although not directly implicating SMEs, the words of Becker and Dietz (2004) can easily be appreciated by smaller companies; “The increasing dynamic of technical progress, the growing complexity of technology and the expanding stress of competition and costs underline the necessity to collaborate in R&D”. Although SMEs are often formed by talented entrepreneurs and are renowned for their disproportionate innovation prowess, the chances of there being an employee within a large firm who holds the key to the project’s progression is greater than within a SME. The financial resources on which SMEs can draw are likely to be comparatively lacking, so that advancement through internal pathways is a less viable option. On the whole, it appears that SMEs feel more pressing need for external assistance, and literally have less to lose. Open Innovation practises would seem the obvious way to achieve such pairings. The conscious effort to find companies that possess mature knowledge and those who deal in emergent technologies may well result in unusual yet powerful alliances, that may not have occurred if the collaboration had been coincidental or the knowledge procurement process less concerted.

2.6.3 Collaborations with different partners

The category into which each collaborator falls can be generalised, even though variety within each category may be large. The basic groups are seen to be: Companies, Suppliers, Clients, and Research Organisations (Miotti & Sachwald, 2003)

Collaborations with Suppliers are perhaps the most recognised as having a positive impact on novel innovation, and viewed as possibly the most effective (Nieto & Santamaría, 2007). This would seem logical as Suppliers are already in close contact with the company, and possess highly technical knowledge that is immediately relevant to the development taking place. Even if the technology being utilised is very young or ground breaking, a successful Supplier from a related field is likely to be apprised to some degree, allowing them appreciation of the underlying science and the experience necessary to help further development. Whilst access to this high level of expertise is extremely valuable, it is likely to be restricted to the technology sector in which that single supplier operates. If the bulk or crux of the development project lies solely within the specialist domain of the supplier, then their contribution is very well received. However, if their expertise has little relevance to any other aspect of a multifaceted innovation, then their value is limited due to their specificity.

Companies that compete in the same niche are likely to have similar capabilities and be interested in targeting similar opportunities, so on face value it would seem that such alignment may facilitate collaboration. However, it appears that involvement with competitors in fact has a negative effect on the degree of innovation novelty (Mention, 2011). When information is sourced from competitors, resulting activities tend towards imitation rather than innovation, and when partnering directly with them neither party brings new knowledge that can trigger novel development. Li and Vanhaverbeke (2009) assert that inter-industry differences between collaborators have a dominant positive effect on degree of innovation, which clearly implicates competitor relationships as less favourable as they will be within the same industry. Partnerships with companies that are not in direct competition are immediately less sensitive with respect to intellectual property concerns, and fulfil the broad criteria for the combination of different knowledge domains that appears to be pivotal. Differences in company size offer dynamics in a relationship that can be positive or negative. A SME can benefit from the great resources that a large organisation may bring to the table, but may also have fears over control, ownership and exploitation (Senad, Ljiljana, & Deborah, 2006) when dealing with a powerful entity that is highly capable of competing.

Involving Clients in the design process can surely assist development of a product that better fits their needs, and this is a methodology that has long been valued for guiding product development. It must be pointed out that clients generally look to their supplying company for competencies that they do not possess, otherwise they would be undertaking their own design and manufacture. Thus it is less likely that high level innovations will be conceived with them, or at least their contribution as a collaborative partner may be less than in other alliances.

The contributions of these various entities should not be further understated, as in many instances there have been considerable successes, and the spark for new-to-the-world innovation can occur at any moment. However, when seeking circumstances that offer the greatest potential for success in an endeavour, one would evaluate all contributing factors and follow the guidelines that have emerged from the existing body of knowledge. When pursuing Radical Innovation, an undertaking that is by nature expected to be risky and expensive, this is especially prudent. A better understanding of what circumstances most consistently promote such innovativeness will allow companies to focus their activities appropriately, perhaps affording higher confidence and justifying the considerable resource commitment.

2.6.4 Collaborations with Research Institutions

After considering the factors that affect the likelihood of novel innovation occurring in various collaborative pairings, it appears that most of these concerns are less prominent in alliances involving Research Institutions. The diversity of technical expertise within universities ensures that there will be a whole spectrum of knowledge available, and the combination of different knowledge domains can occur no matter what industry the commercial partner is in. Furthermore, the knowledge that is contained within the university is expected to be of the highest level, as universities not only strive to keep abreast of the current state of the art, they are often the most capable at breaking new ground and furthering knowledge within a specific field. According to Faems, Van Looy, and Debackere (2005), as universities are on the cutting edge of technology, they are well placed to contribute to radical innovations. They explain that collaborations with different partners coincide with different types of innovation outcomes, specifically indicating universities and research organisations as being associated with new products rather than incremental innovations. Miotti and Sachwald (2003, p. 1485) agree that "Co-operation with public research institutions is most attractive to firms that conduct R&D at the technological frontier". One of the primary functions of a university is new-to-the-world research, and as such they are experienced in pursuing this. Lööf and Broström (2004) agree in their study of large companies, claiming robust evidence of increased innovation performance especially in manufacturing firms.

The role of universities traditionally lies in academia, both for the advancement of technology and to train minds, imparting skills which in the majority of cases will be used for employment which benefits economic development. University - Industry collaboration achieves the same ends – technology advancement, employment and economic development - but through an alternative, complementary means. The issue of competition is largely negated, as the university does not have a presence within the commercial marketplace and is generally not in the business of manufacturing. By the same token, Intellectual property is held in higher confidence, as there is less motivation for it to be used by the university in a competitive manner.

Another element that may be afforded by universities is immediate access to national and international connections, as these connections are often well developed. It appears that New Zealand SMEs are quick to look overseas for their collaborative partners, possibly because of the lack of local circumstances that initiate such pairings (Davenport, 2005). In contrast, Flores et al. (2009) suggest that proximity is important for collaboration with universities (yet not

essential), but also explain that recognition of local potential partners is a key initiating factor, and in this way offer some agreement. Clifton, Senyard, Pickernell, and Packham (2007) support the evidence that innovative, high-growth firms readily utilise non-local networks, but there is definite value for them in regional networks as well. To combine these points, it may be suggested that universities can provide local collaborative support, but at the same time promote the international aspirations of SMEs that seem to be commonly held.

2.6.5 Relationship Formation, Trust and Culture

Whilst theorising in this manner can formulate some interesting hypotheses, the real world intricacies that occur will dictate whether these can in fact proceed as postulated. The most commonly cited factor that appears to affect university-industry collaborations is the difference in organisational culture (Bjerregaard, 2010; Braun & Hadwiger, 2010; Horowitz Gassol, 2007) and trust (Braun & Hadwiger, 2010; Davenport, Davies, & Grimes, 1999; Flores et al., 2009; Senad et al., 2006; Story et al., 2008), which is also a prominent factor in general business to business collaborations.

Li and Vanhaverbeke (2009) found that whilst there are positive effects from combining the technology specializations of different countries, these can be partly or wholly overwhelmed by learning and communication concerns. Human culture differences may have a similar impact as organisational culture differences. It could be hypothesised, for instance, that New Zealand and Australia may be able to collaborate more freely due to the similarities in culture, yet benefit from the differences that are surely present between their respective industries. In a similar manner, if the organisational culture of a potential collaborator is akin, then formation of a relationship is facilitated. If the organisational cultures are markedly different, there may be issues that prevent or overwhelm the collaborative effects.

Trust is built through personal interaction and relationships that are formed (Senad et al., 2006), there being advantage to these being loosely-defined rather than formal (Story et al., 2008) and it would seem logical that any culture differences may inhibit these types of socially styled relationships from forming. Companies of similar size that operate in the same industry and region are likely to relate to one another, yet the university next door may be seen as organisationally foreign. Universities are clearly different to many entities found in industry in terms to their primary operating purpose, and as such it can be understood that there may be large gaps to span before positive collaboration occurs. Bjerregaard (2010) suggests that there are individuals who can bridge the cultural gap between universities and companies, most probably those who have spent time in the academic world and industry and thus have an

appreciation for the concerns of both. Alternatively, some companies may have gone some way to the “adoption of academic norms” (p106), and thus are operationally closer to universities. Bjerregaard (2010) refers to an “entrepreneurial university” (p106) complementing “academic firms” (p103), in that both have an understanding of or undertake practises that are akin to the other. These universities still have the primary function of education, but perhaps have adopted a stance which connects learning, research, technology and the logical implementation of their output in the real world.

D'Este and Patel (2007) found that the characteristics of an individual researcher have a greater impact on interactions with industry than the overall characteristic of their university or department, which strengthens the idea that relationships at the personal level can be pivotal in the formation and success of such alliances. However the instigation of a university-industry partnership has to occur before these relationships can develop (unless it was a past relationship that introduced the two parties). Perhaps the informal culture that is present in New Zealand (and Australian) society can go some way to bridging cultural gaps and promoting relationship formation. Thus the attitudes of the business, university and society remain as important factors that enable this, a strong connection is built and maintained through relationships nearing the personal level, and the sum of both is a strong complementary partnership that can proceed with the innovation process.

2.6.6 Perception of universities as potential partners

Despite the large academic interest that is currently being shown in Europe and the USA, partnerships of SMEs with universities are not occurring as often as would be expected given the potential benefits for improvement in innovation performance. Collaborating with Research Organisations may be advantageous, but is infrequent and traditionally not viewed positively according to Nieto and Santamaría (2007). Lööf and Broström (2004) note high value and notable incidence of university collaborations with larger firms, but found less impact on the product development activities of SMEs. In their study they attribute this to larger firms being more financially able to undertake development of a radical nature, and observed few SMEs engaging in such alliances thus restricting their prominence.

However, the partnering that is addressed here utilises university resources that are somewhat removed from education activities – the academic staff and faculty facilities are used for their expertise rather than the students themselves. Larger firms understandably focus on this source as it offers immediate access to advanced knowledge, and they have the financial ability to facilitate this. Start-up firms may be able to form a partnership in the same manner,

but there is also the attractive alternative of enlisting undergraduate students, an option which is accessible to even the lowest-funded entrepreneur. Whilst the level of expertise being tapped at the immediate point of contact is not of the same depth (yet), an entry to the combined knowledge that supports the student is afforded.

It appears that companies are not aware of or are overlooking universities as potential collaborative partners unless there is a catalyst for doing so. Flores et al. (2009) suggest that proximity to universities should make firms aware of their capabilities, but that it takes motivated professors and entrepreneurial firms to galvanise action. Horowitz Gassol (2007, p. 4) explains that "links with businesses arise as *ad hoc* solutions to intermittent situations", and that university culture is not traditionally equipped to handle this. Clifton et al. (2007) presses the need for more coordination among universities, in order for them to play the dual role of technology generation and also diffusion of the knowledge. Perhaps if universities are adequately geared towards collaboration then the perception in industry would be more positive, and more companies may approach. It is unclear whether the push for collaboration is best initiated by the university, the SME, or a facilitating body such as government organisations that are formed for such purposes.

Mandates, policies or initiatives that are put in place to drive university-industry collaboration are positive (in principal), as informing firms of the benefits is essential to their acceptance of it as a viable option. Many researchers have considered the requirements for and implications of government involvement (Braun & Hadwiger, 2010; Clifton et al., 2007; D Este & Patel, 2007; Davenport et al., 1999; Fontana, Geuna, & Matt, 2006; Giuliani & Arza, 2009; Goh & Thorpe, 2008), giving many solutions and approaches that suit the specific country and situation on which they focus. Davenport et al. (1999) links this thread with the seemly primary considerations of trust development and culture differences. However, not all alliances will be born from government-backed initiatives, and indeed, it would seem desirable for collaboration to occur with as little drain on public funds as possible. Any money that is invested will return greater value if the intricacies of university – industry collaboration are better understood.

2.7 Knowledge Management

Collaboration, Open Innovation and Knowledge Management share much overlap, and mention of one naturally leads to discussion of the others. Such networking activities are often undertaken to gain access to knowledge, or at least there will be substantial flows of knowledge-containing information between the parties. There are different forms of

knowledge that must be recognised, which is necessary when discussing the issues surrounding its sharing, protection and acquisition.

Management of knowledge can be crudely divided into three areas of concern: Knowledge flow into a business, its flow out of a business, and organisation of knowledge with the business itself. Each area has its own individual issues to be taken in to account, and also factors that are common to all. Knowledge is most commonly recognised as either Explicit or Tacit, or more simply, information or know-how (Dyer & Singh, 1998). Explicit knowledge is codifiable, and thus lends itself to transmittance through many communication pathways, both traditional and modern. Tacit knowledge is embedded in people through experiences and learning, and is generally more difficult to transfer. The extraction of tacit knowledge through knowledge transfer processes is an important issue for both internal teams and external networks, and central to the development of capability (Harris, 2009). That is not to say that management of explicit knowledge isn't of concern to businesses, but argument can be made that handling of such data is better understood.

2.7.1 Internet sources and social media

Data availability has skyrocketed dramatically with the advent of the internet, a change that is remarkable both in its onset and its global acceptance and adoption. The information age has also brought with it unprecedented activity in inter-personal connections, that can be anywhere from purely social through to professional, even exploitive, or a proportioned blend of all at the same time. Discussion of the opportunities that this technology affords is essential as its impact on knowledge distribution is pronounced, but in no way can all facets of such a complex phenomenon be addressed here. Rather, identification of key areas is offered, those that are observed as overarching considerations for an entrepreneur looking to effectively communicate and manage knowledge. As confirmed by Harris (2009, p. 220), "new ways in which to manage tacit knowledge and information can assist them to achieve competitive advantage".

Whilst an extremely useful information source that should not be ignored, internet resources are not necessarily easily tapped for in-depth technical information. The popular belief is that everything is available on the internet; while this anecdote may ring true for many information gatherers, it is not a guarantee for the technical researcher. Companies developing high-tech products will require extremely specific knowledge, likely tending towards the cutting edge if the project they are pursuing is ground breaking. Specific knowledge is difficult to capture, often being confidential or in a form that is not readily applicable in the required context

(Blessing & Parker, 2010) whereas common knowledge is by definition well reported. Many different opinions, applications and partial solutions will be uncovered in an internet search, sometimes as many variations as there are authors. The glut of unverified data presumably increases as time passes, contributions continuously being offered. As intelligent information retrieval systems evolve, access to targeted and reliable information may improve, but the raw information that is gathered from the internet may need extensive adaption, validation and much other processing to render it to a form that can be successfully applied to a particular context. Industry experts are themselves a great repository of information, and of course the ability of a human to recall and supply relevant knowledge is far more efficient than a researcher trawling the internet using common search engines. In similarity with the internet, however, the accuracy, completeness and level of technical depth that a verbal source provides can be greatly varied.

At least with human interaction, the issue can be relatively quickly dissected and broken down so that the core problem can be exposed and addressed. With proper communication of the problem, direction can be achieved towards a solution and minimal processing of superfluous data is required on the part of the entrepreneur. It is expected that if a topic lies far from the core competencies of an individual, more learning would be required to up-skill themselves and gain required knowledge in this area. This could be a laborious task performed solely from internet resources, and perhaps result in an incomplete understanding of all the problem's intricacies. It is difficult to argue that having face-to-face interaction with a technical expert is inferior to observing the same expert's knowledge expressed over the internet.

A video conference with a distant specialist is definitely preferable to no contact at all. Thus social media has been a great boon in opening communication channels and facilitating networking, regardless of whether a resulting relationship is conducted over the same medium. Professional networks encourage cooperative relationships through which tacit knowledge can be transferred. Entrepreneurs in a start-up situation may have no industry contacts at the outset, whereas an established company is very likely to have relationships with suppliers and other companies that can afford them immediate business connections. Such avenues of knowledge acquisition are great enablers to companies lacking geographic proximity to knowledge sources, as isolated companies are more likely to look overseas and do so early in their growth paths (Davenport, 2005).

2.7.2 Proximity in knowledge acquisition

At a time when global business activities have never been more prominent, there is also considerable discussion regarding the effects companies being geographically close to one another. These regions are often called "clusters", where "firms and labour congregate in order to take account of increased factor rewards" (McCann & Gordon, 2000). A proportion of the literature understandably focusses on general business operations in a financial sense, which is valuable, but perhaps one step further removed from the focus of this study. There are definite implications for innovation, however, which immediately has relevance for companies pursuing product development.

Clifton et al. (2007, p. 339) summarize the work of McCann and Gordon (2000) by explaining that the advantages of geographically based clusters and networks are found in three ways: Agglomeration, which gives external economies of scale, scope and complexity, Industrial complex advantages which reduce transaction costs through location, and social networks that ease knowledge flows. Obviously the flow of knowledge is a key factor listed here, and especially if it is accompanied by improved scope and technical complexity. Clifton et al. (2007) also report that firms do derive significant value from face to face interaction with local strategic contacts, however warn that "caution should be exercised in overemphasising the purely spatial proximity aspects of clusters at the expense of institutional or cognitive proximity". Davenport (2005) supports this and muses that in New Zealand organisational proximity may be dominant to geographic. This suggests that there are more factors that need to be present for a positive effect to be realised. Institutional proximity is discussed previously in section 2.6 with regard to culture differences in collaboration, supporting this point that another entity can be close in location but foreign in nature or distant in capabilities.

Davenport (2005) also acknowledges the historical evidence that proximity promotes aspects of business performance, but also shows through a study of New Zealand SMEs that many achieve growth and international success without reliance on localised knowledge sources. It is suggested that his may be due to alternative paths for SME growth being as viable as those that acquire knowledge from other firms that operate in the same sectoral and geographic space. The avenue that is steered down is influenced by the absence of a substantial domestic market, leading to rapid internationalisation by necessity, which in turn introduces the customer demands of foreign markets. The knowledge acquisition focus then shifts to be an international one. Where a firm's market is local, it follows that local knowledge and specialisation will naturally be considered.

Of course, scale is an important consideration in predicting the impact of technology clustering regardless of where and how large is the market being targeted. A main centre in New Zealand clearly does not have the population and industry that is found in many overseas instances, "Silicon Valley" being a highly studied example. This is suggested by Clifton et al. (2007, p. 367), referred to as "knowledge infrastructure", and that any assumptions made would have to take into account the categorisation of the region and be adjusted to their differing environments. Furthermore, exemplary cases are often reviewed and these may have little relevance to ordinary situations and average companies. On a world scale New Zealand is as sparsely populated as lagging areas in other industrialised nations, and it may be a struggle to adapt the conclusions drawn in foreign studies. McCann and Gordon (2000, p. 513) note that "rewards are only exhibited over a limited spatial domain at the locations where such congregating takes place", as the cost of overcoming distance imply that there is a "finite spatial limit over which such net benefits can accrue". In a cluster of unrelated businesses, as is commonly found within industrial areas in New Zealand, there may be considerable physical distance between other firms that are relevant to a specific industry sector.

The results of Huggins and Johnston (2009) suggest that SMEs from less competitive regions utilise non-local networks more often, and value them higher, but it is those firms that draw from all available sources that are more successful. Start-up enterprises are expected to value local networking opportunities highly at the beginning, as they are at the very start of their product development activities and further reaching connections have not been established yet (Davenport, 2005). As they progress and the project layers increases in complexity, their requirements will change and knowledge will have to be sourced where available, local or otherwise.

Regardless of whether interaction is nearby or in a foreign location, it appears that external sources in general are of great importance to the knowledge requirements of a small business.

2.7.3 Impact of external knowledge acquisition activities

Small start-up enterprises are likely to have a lesser breadth of knowledge conglomerated within the organisation than a large enterprise, quite simply due to the lack of employees. The depth of knowledge in some fields can be considerable as entrepreneurs often have expertise in their field, but it is unlikely that this extends to all of the many dimensions that make up a high-tech development project. It can therefore be expected that an entrepreneurial start-up will be required to tap into knowledge from external sources in some way. This is not to say that this is exclusive to start-ups, as innovation performance is also better for other companies

when knowledge and capabilities are acquired from other organisations rather than relying on in-house innovation (Batterink, 2009; Laursen & Salter, 2006). Rather, there is the implication that what is valuable even to a well-resourced outfit could produce an even more marked effect when applied to a start-up. This is not explicitly confirmed in the literature that was reviewed for this study, but evidence for the value to SMEs and start-ups is strong.

Sustainable competitive advantage is underpinned by knowledge-based activities, and knowledge acquisition is especially critical for SMEs survival (Gils & Zwart, 2004). If compared with larger enterprises , in particular, SMEs tend to place more emphasis on management of knowledge in tacit forms , and furthermore communication channels are inter-firm rather than internal to the organization (Corso, Martini, Paolucci, & Pellegrini, 2001). These communications and strategic alliances result in improved firm performance (Gils & Zwart, 2004) but not without raising concerns that can discourage some small companies.

Loss of competitive advantage can cause hesitation in forming alliances (Gils & Zwart, 2004), and this is understandably a concern when dealing with competitors as collaborators. It appears that formalisation of the relationship can go some way to allaying these fears, yet small companies tend to operate with very informal arrangements. According to Kale, Dyer, and Singh (2001) “companies that make proactive investments in establishing a formal structure and systems to manage their alliance activity are better positioned to enjoy greater alliance success and value creation”. So whilst the acquisition of external knowledge can have a marked effect on innovation, care must be taken not to induce the opposite and risk loss of competitive advantage. Prior experience in sourcing external knowledge would streamline this process, as it would for many aspects of the innovation process. The very nature of start-ups means that there are often entrepreneurs involved who have strong technical knowledge in their field, but quite possibly are under experienced in the workings of the small business environment. There is definite potential for encountering pitfalls that may be avoided with a systematic approach.

3. Research Methodology

3.1 Introduction

Case Study Methodology is commonly used when investigating a "contemporary phenomenon within a real-life context" (Yin, 2009, p. 2), and is used in this study as a method of theory building in an inductive, exploratory manner. This section describes why a case study approach was chosen for this research project, and also enters into discussion of the limitations that are observed or inherent in the process.

3.2 Case Study Methodology

3.2.1 Selection and justification of methodology

First it was necessary to evaluate whether a case study is the appropriate method of undertaking research in this instance. The overall research problem addressed in this study is "*How do start-up enterprises undertake the early stages of technology-based Product Development?*"

Exploratory and Descriptive Research

As prescribed by Yin (2009), a case study has a distinct advantage over other research methods when the question being asked begins with "how" or "why, and the researcher does not have control over the contemporary events that are being investigated.

Questions that begin with an interrogative "how do" statement are candidates for investigation by case study, as there is the suggestion that probing into the details of a phenomenon is required. In this study the research question is seen to be of the form best addressed through both exploratory and descriptive case study approaches, there being large overlaps between these methods as pointed out by Yin (2009). As investigation into the phenomenon is requested, there is "justifiable rationale for conducting an exploratory study, the goal being to develop pertinent hypotheses and propositions" (Yin, 2009, p. 9). The investigation presented seeks to contribute to the literature and current understanding of the subject area, and suggest a direction for further research, which could perhaps be performed in an explanatory capacity.

There is also clearly need for insight into the manner in which the subjects behave, thus justifying descriptive elements of the case study methodology. This is reinforced and refined by Perry (1998a, p. 787), who notes that such research problems often take the form of "How

do" rather than "How should", extending a descriptive query rather than a prescriptive one, or being predictive as is often intended by a quantitative research. A major intention of this research is to describe the current state of the phenomenon.

The data that is expected to be collected is related to the research area identified in the literature review, and formalised with the research questions that are posed. All the research questions use the interrogative pronoun "what", in these instances used to enquire into management aspects of entrepreneurial start-up enterprises. Questions such as these can be seen as exploratory and descriptive in nature, as once again attempt is not being made to explain a phenomenon; rather it is the intention to expose. However, there are other research methods that can be used to undertake descriptive or exploratory research, thus this explanation has been given to explain why case study methodology was chosen over other tools.

Research Method

Research Question 1 initially appears to lend itself to archival analysis or survey investigation as it is probing for product development practices of start-up enterprises. But as the wording asks for practices that "can be" adopted rather than "are" adopted, it is seen that the task at hand is more than just recording what has happened in the past; the circumstances and issues surrounding the phenomenon and the opinions of those involved must be reported also. Research Questions 2 and 3 also require in-depth discussion to properly address them, and their intention is not solely to evaluate the prevalence of a feature. Although a survey-style approach can be used as a sub-method of the case study protocol, it is not the overarching research methodology being employed.

Overall, it is the nature of the information that is to be gathered and the research goal that dictates the research methodology. The data are not expected to be of the quantitative type, and the project is not intended to be predictive of certain outcomes. This research project seeks to elicit information about management practices where respondents draw from their open first-hand experiences. Responses are to be gathered from open-ended questions, which permit the respondent to touch on any issue they see as relevant to the topic. Whilst quantitative analysis could be carried out on these results, the lack of formatting means that this method is not pre-disposed to it. In addition, much of the value in this data gathering approach comes from discussion around the issues raised, such that whilst it is notable if multiple respondents identify the same broader issues, their individual take on the situation is where the richness of information is found.

As previously discussed, it is not the intention of this study to undertake theory testing, therefore Cause and Effect relationships are not targeted, and these are more commonly associated with surveys and experimental techniques. In addition, the researcher does not have behavioural control over the events, which further excludes experimental methodology from the possible research techniques. The phenomenon that is being observed is not able to be removed from its context in order to "control" possible influencing factors in the manner that experiments do. Rather, the context encompassing the focal issues is of interest as the interaction in the real world creates the phenomenon. Investigation must take place without detrimental disruption to the situation.

3.2.2 Case Study Structure

In keeping with the structure suggested by Yin (2009), the structure of this case study is Holistic (single unit of analysis) and involving multiple cases. A multiple case study approach is appropriate for research in this instance as there was not a singular case that was critical, rare, or that represented significant or revelatory theory. Furthermore, access to multiple respondents was possible, with all cases being valid representations of a phenomenon occurring in a certain context. Thus it was advantageous to observe more than one case as this provides the opportunity for replication logic. Distinguished from the sampling logic that is commonly used in empirical investigations, replication logic is in this instance used to search for similar results across several cases.

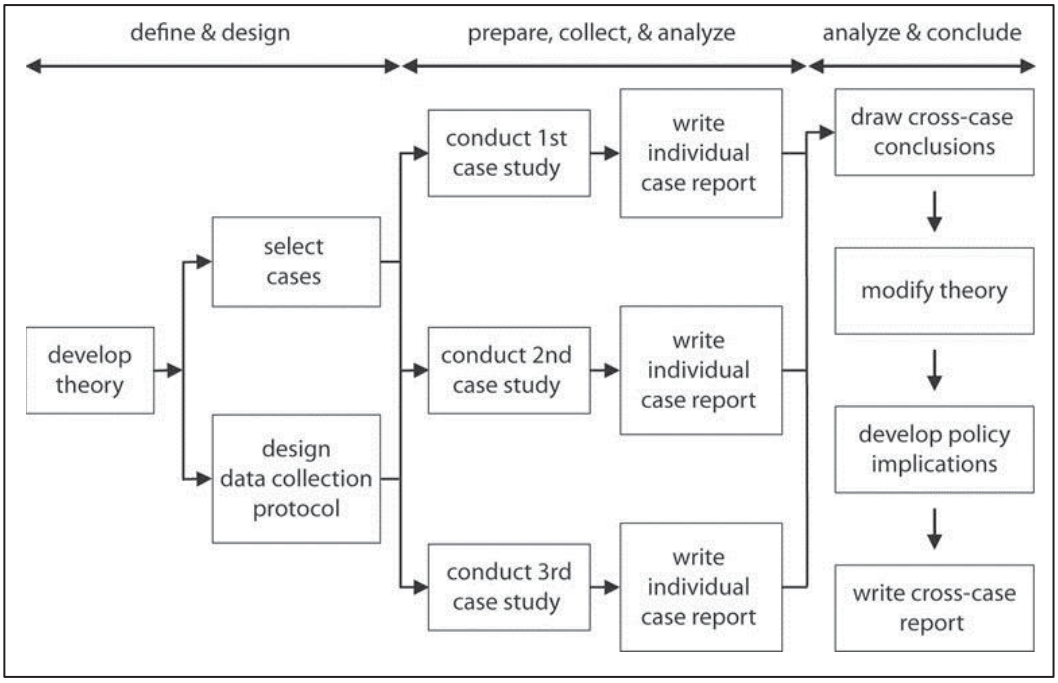

Figure 2 **Source: Yin (2009)**

The case study procedure was based on the layout shown in Fig. 2.

Unit of Analysis

Individual products are not the unit of analysis, as respondents are asked to draw on all their product development experiences. Whether the experience comes from early attempts at development, previous work history, or several products conjointly developed as a product family, it is not necessary to single-out one product. Rather, the respondent's NPD experiences are the focus, and responses will be evaluated in terms of their relevance to that. The manner in which the enterprise as a whole (albeit small) company performed its NPD activities is investigated. The entrepreneur's experiences from their immediate business venture as well as wisdom from previous lessons are taken into account, as it is their accumulated knowledge which give them perspective on the journey they have taken.

Therefore, the Unit of Analysis is the "Start-up Enterprise". This is the entity about which the discussion is held (Patton, 1987).

3.2.3 Limitations of Case Study Methodology

Whilst being appropriate for the research project in this instance, case study methodology does have disadvantages and limitations that must be discussed in order to properly place the resulting study with respect to its academic rigour.

A common criticism of case studies is that the results may not be used to scientifically generalise to a population as is the intention in purely statistical, quantitative research. This is neither the aim nor an expectation of this study; rather, generalisation to theoretical propositions is pursued (Yin, 2009). Expanding theories is the goal, rather than to establish frequencies and purport significance that could allow prediction. To that end, this study has from the outset made clear its intentions, and the research design has deliberately been chosen to direct investigation along an appropriate path. This is evident in the careful selection of the research problem and research questions, with explanation in Section 3.2.1.

The level of scientific rigour in case studies is, according to Yin (2009, p. 14), often sub-standard and "has not followed systematic procedures". He attributes this to there being few texts besides his own that present methodological procedures that investigators can follow, but notes that their numbers are increasing. Of course, this observation was made previous to the book's composition, and that very text itself goes a long way to remedying the deficiency. Having access to this was key to formalising methodology, as it is seminal and widely regarded as the single most necessary resource on which case study design should be based. The work

of Eisenhardt (1989) is referred to heavily, also being a seminal text on the subject and recognised by Yin in his later revised editions. A modern proponent of case study methodology especially focussed on use in postgraduate research is Perry (1998a), who lends much justification for its use in this area. Furthermore, he offers a clear guide to the procedures that should be adhered to, a step-by-step approach of the type whose absence was earlier lamented by Yin (2009).

It is through strong adherence to the methodology championed by these recognised figures that scientific rigour is brought into this study, and it is the clear definition and declaration of intention at each stage of the proceedings that allows this rigour to be observed and qualified by any reader.

3.3 Selection of Cases

3.3.1 Business Incubators

The start-up enterprises observed in these case studies were sourced through their connection with business incubators, one based in Auckland, New Zealand and the other in Queensland, Australia. The justification for selecting companies that were involved with business incubators goes beyond the convenience of access to many entrepreneurial entities. There are several factors that make such businesses desirable for observation.

Business incubators are, by profession, involved in mentoring small businesses, especially those that are seen to have a commercially viable product concept. It is not the norm for them invest time or even start-up capital in a dubious prospect. It is therefore likely that the businesses accessed will be pursuing more innovative projects and "new products" as defined in Section 1.5. However, cases were screened further to ensure sufficient levels of innovative activity, and indeed all that were put forward did qualify.

Business incubators offer mentorship that is based on the expertise and experience of their staff. Companies that are involved with the incubator then have access to the depths of knowledge that are contained there, and there is direct application to their project; therefore it can be expected that many product development practices are prompted by the incubators. It is likely that a much greater diversity of techniques would be available to the entrepreneurs than, for example, a lone self-motivated inventor with no product development experience at all, possessing merely a bright concept but no direction. As this research project seeks to elicit commentary on the experiences and opinions of entrepreneurs, it is valuable to engage with

those that have had a greater range of methodological experience from which they can form their perspective.

It may be argued that the fact that companies are actively biased towards business incubator methodologies skews research findings towards their teachings. Whilst it is certain that these methodologies will be adopted by companies, whether wholly or partially, the key point is that they are able to make valuable comparison and evaluation. They are in fact trialling these techniques and are in a position to give critical comment. In contrast, the aforementioned "lone entrepreneur" has only their instincts to go by, and may miss the opportunity to form a broad perspective. The methods offered by the business incubator are *in addition* to the ones that the lone entrepreneur naturally gravitates towards. It is against these natural tendencies that the techniques that were adopted will be vetted.

3.3.2 Number of cases

The number of cases selected for this research was physically governed by access to willing respondents, in that it was not possible to limitlessly add cases as needed in order to reach "theoretical saturation" (Eisenhardt, 1989), but the quantity settled-upon falls well within the guidelines put forward by many writers. Perry (1998a, p. 793) summarises several authorities opinions by saying "the widest accepted range seems to fall between two to four as the minimum and ten, 12 or 15 as the maximum", which neatly qualifies the 8 cases observed for this research as acceptable by all and unacceptable to none.

Whilst it may have been possible to source more respondents, the advice of Eisenhardt (1989, p. 545) was heeded once more as with more than 10 cases it begins to be "difficult to cope with the complexity and volume of the data". Furthermore, Patton (1990) expresses that the number of cases is less relevant than the richness of the information gathered, and the researcher is charged with the task of effectively extracting value from whatever research design is implemented. With these guidelines and considerations in mind, it was felt that the number of cases that were interviewed is appropriate to the academic level of the research project.

3.3.3 Case diversity

This research project focuses on Product Development in small, start-up enterprises as defined in Section 1.5. Therefore, cases selected for observation must fall within this definition in the first instance. Of the eight enterprises surveyed, four were developing web based software products, two developing standalone software, and two involved in physical products. Of the

two physical products, one had elements of software in their final market offering, and all used computer based design tools to some degree. This illustrates the importance of computers and software engineering to modern products, and once again justifies the inclusion of such innovations in this study.

However, the cases selected differed in many ways which provided variety within the context of small start-up enterprises. This is desirable as responses from a broad cross-section of the population are more able to express the perspectives that exist. This is not with the intent to generalise findings to the population as in statistical, quantitative research, but rather to be able to generalise to theoretical propositions (Yin, 2009). Therefore, input from diverse areas of the research field will afford greater theoretical richness and better capture the complexity of the issue at hand. This is in line with the recommendations of Patton (1990) in that regardless of the strategy used for selection, the important constant is that the cases chosen be rich in information.

In addition to the enterprises and product offerings being diverse, the backgrounds and skills of the entrepreneurs themselves are varied. Different industries, levels of qualification and product development experience were represented, which all contribute to the breadth and strength of responses that were elicited.

3.4 Interviewing Technique and Data Collection

3.4.1 Interviews

The director/entrepreneur of each enterprise was interviewed, with the interviews lasting between 1 and 1 ½ hours each. Flexibility was given to allow longer duration, as the primary concern was quality of the data collected and continued discussion would only increase the chances of eliciting further valuable responses.

3.4.2 Data Collection Protocol

The interviews were conducted in standardized manner, in that a framework of general questions was prepared that were asked to all interviewees. However, their open ended nature was intended to elicit discussion surrounding the topics raised, and digression into other areas was not restricted provided that the material was relevant to the overall research subject. These formalised questions were supported by probe questions (Perry, 2001, p. 311) which were used to dig for answers in the event that the respondent either digressed from the research subject, or failed to respond in a functional manner. These probe questions were not

pre-decided, as it is impossible to foresee what would be needed in every instance. The probe questions were therefore formulated as the interviewees responses required, and the terminology and phrasing were adapted to suit the respondent.

The interviews could therefore be described as semi-structured, and in this manner respondents were able to discuss at length the issues that they felt were pertinent whilst still touching on broader topic areas that are of particular interest in this study. As expressed by Shaw (1999, p. 61), “a qualitative approach which allows small firms to be viewed in their entirety and permits researchers to get close to participants, penetrate their realities and interpret their perceptions, is appropriate”.

4. Data Analysis & Discussion

4.1 Introduction

The data resulting from the interview phase of this research project is in the form of narrative text, due to the interview questions being of open-ended nature. Very little quantitative data is present in this data set; the vast majority is qualitative evidence, the opinions of the entrepreneurs expressed in their own words elicited through topical conversation rather than rigid survey gathering techniques. Therefore, the method of analysis that is chosen to interpret the data must be one that is appropriate for the type of data present.

According to Yin (2009), there is not a readily available formula or recipe for analysing case study evidence, but guidance is offered on how to achieve a rigorous result. A methodology was used in this research project that drew benefit from two different data analysis strategies: Manual evaluation, and the use of qualitative data analysis software.

Computer assisted analysis is recognised by Yin (2009) as being a valid tool for facilitating the coding and categorising of qualitative data, and can be very helpful. However, the output from the software is far from being the end of the analysis; it is more useful as a starting point, and as another source of objective description. The use of this tool is not intended as a substitute for traditional methods of interpreting data, and the final results of this study are presented on the merits of the manual analysis primarily. The role that the computer played is complementary, an additional method of exposing themes and key aspects of the data, and a visual method of displaying the findings is afforded. As the data is manually dissected the software output can be cross-referenced, to both verify the incidence and relevance of the emerging themes and to highlight the connections between the concepts that are encountered.

Software tools are most effective when a large quantity of data is present, as they provide a method of processing that is rapid and accurate. Whilst the quantity of data from each individual interview is relatively large, the volume of all data combined for the cross-case analysis is of a size where use of the tool is truly warranted.

By approaching the task with more than one technique, the ability to extract meaning from the interview responses is greater. The chance of an important conceptual connection being overlooked decreases, and a more clearly ordered data set is presented with which a human analyst can develop a rich and full explanation.

The manual analysis was initiated by referring back to the original research questions and the case study protocol, to reiterate the purpose of carrying out the research and focus the data evaluation on the evidence that addresses those questions. In open-ended interviews, the answers contain a large quantity of information that provide insight into respondent's experiences directly relatable to the study focus, but also can produce information that may seem less relevant.

4.2 Description of cases

The respondents in this study were assured of complete confidentiality, therefore no discussion of their intellectual property will be entered into, and the focus will remain on management decisions and activities rather than technical specifics.

To this end, the following descriptions of the enterprises and respondents are offered with the intention of providing necessary background to the environment in which the products are being developed, yet no private information will be revealed. The companies have been labelled for identification by letters A through H in no particular order.

Enterprise A

Entrepreneur: PhD qualified, highly technical background in computer science. No previous experience in product development, 2 – 3 years technical industry experience.

Company Structure: Single person start-up, self-funded.

Product: Web-based software. Currently in full-scale testing, nearing production.

Enterprise B

Entrepreneur: Undergraduate engineering student. No previous background in product development or industry experience.

Company Structure: Single person start-up, some work contracted out under profit sharing arrangement.

Product: Stand-alone software application. Currently in technical development phase.

Enterprise C

Entrepreneur: Degree qualified. No previous background in product development, 5+ years in financial sector.

Company Structure: Single person start-up, some work contracted out.

Product: Web-based software. Product is on the market.

Enterprise D

Entrepreneur: Masters qualified, non-technical background. No technical industry experience, but 15+ years experience in the artistic form that the technical product deals with.

Company Structure: Single person start-up, self-funded.

Product: Web-based software. Currently in product testing phase, nearing launch.

Enterprise E

Entrepreneur: PhD qualified, highly technical background. A previous attempt was made at commercialising an initial design. 5+ years technical industry experience.

Company Structure: Single person start-up, self-funded.

Product: Web-based software. University spin-off. Currently in full-scale testing, nearing production.

Enterprise F

Entrepreneur: Undergraduate engineering student. Formal training in product development, but no industry experience.

Company Structure: Single person start-up, self-funded.

Product: Stand-alone software application. Currently in technical development phase.

Enterprise G

Entrepreneur: Background in commercial markets and investment, consulting for start-up enterprises, involved in several previous NPD projects.

Company Structure: 2 person partnership, investor funded

Product: Physical product for domestic energy sector. Currently in technical development phase.

Enterprise H

Entrepreneur: Degree qualified, highly technical research background, 5+ years industry experience in engineering research.

Company Structure: Single person start-up, many aspects of technical and aesthetic design contracted out. Funded by government grants, utilising student project work, and some investment.

Product: Physical electronic product with software interface. Currently entering initial production runs.

4.3 Interview Data

4.3.1 Data Analysis Procedure

A systematic procedure was formalised before analysis of the data took place. This approach was taken in order to guide the research down a path of rigorous methodology, with the aim of achieving the research goals of this project. By adopting a pre-ordained methodology, assurances can be made that:

- Each data set is treated in the same manner.
- The focus of the analysis lies on the appropriate aspects of the data, relevant to the research goals.
- The extracted themes are appropriate to the scope of the research project.

Open-ended interviewing techniques elicit a large quantity of data which will include in it elements that are highly relevant to the subject, but also elements of lesser interest and even those irrelevant to the focus area. A good analysis should have provision for identifying the relevant portions of the data and dealing with them appropriately, but also a method of screening those elements of lesser relevance to ensure that an important connection is not overlooked or lost during codification.

With this in mind the strategy for data analysis was formed, using the recommendations of Yin (2009) as the primary reference. The most preferred strategy is one that relies on the original objectives and theoretical propositions that were set out at the beginning of the research project. The extraction of meaning from the data must be guided by the same factors that provided the impetus for the initial data gathering phase. Therefore the codification of data was orchestrated to expose those elements that have appropriate relevance.

In addition to this, a descriptive approach was utilised as much of this research project is performed under descriptive case study methodology. The definitions and delimitations of scope (section 1.5) serve to outline the focus and depth of the cases, and provide the theory of

what is important to describe when performing the research. This “descriptive theory” is the criteria by which the data is analysed in a descriptive case study (Yin, 2003).

Fig. 3 presents the procedure by which the data was handled and the aforementioned strategies applied.

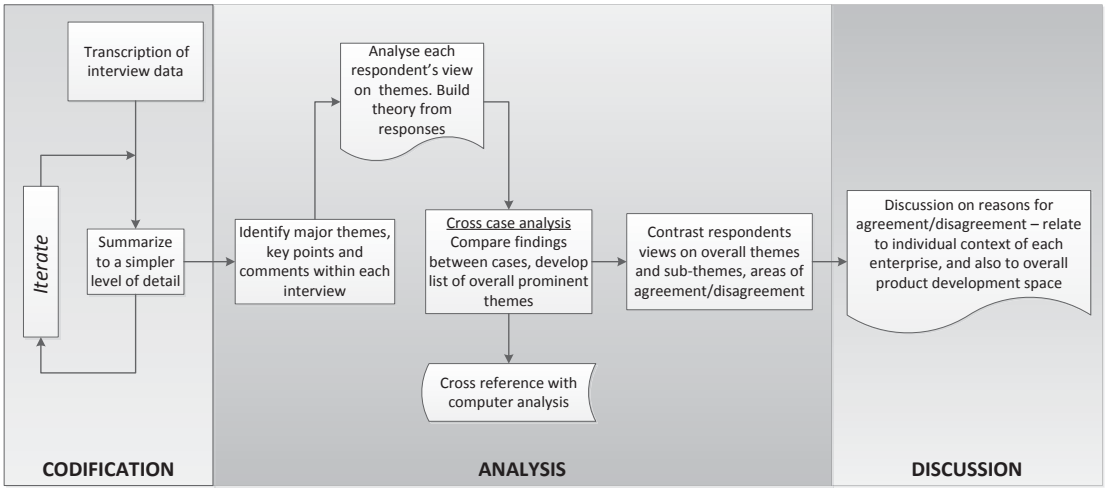

Figure 3 Data Analysis Procedure Source: Developed for this research

The first step was to transcribe the interview data. All interviews had been recorded so that every comment could be fully captured, and sentiment retained for later reference. Verbatim transcription is not necessary in this instance, nor is it preferable as human speech contains many features that are not directly codifiable. Figures of speech, colloquialisms, and hyperbole, for example, make literal extraction less desirable, as well as implied content that requires the listener to fill in the gaps by subconsciously analysing the speakers tone, body language and other natural communication traits. The data was therefore put into text through careful extraction of meaning from the interview recordings. The respondents wording was retained preferentially, but where necessary their intentions were conveyed through terminology of the type that is commonly used in Product Development literature.

By iteratively summarizing the raw interview data as described during codification, there is opportunity to identify and capture the pertinent elements whilst reducing the volume of information to an observable size. Thus the full content of the data is reviewed, and the relevant themes are distilled from raw data down to a form that is appropriate for theory building within an exploratory study.

The main analysis itself began with the identification of the major themes that emerge from each interview, consisting of the key points and supporting comments that the entrepreneurs

offered. Initial theory building was then carried out on the individual results of each case. The themes of each case are then brought together and a cross-case analysis is undertaken, which begins with overall themes being developed from the data of all cases combined. The findings are cross-referenced with those generated by computer software analysis, to provide further screening for relevant items. Analysis is then undertaken which contrasts the overall emergent themes with those of the individual cases, and areas of agreement or disagreement between cases. Finally, the connections that have been identified are discussed with reference to the companies, the environment and situation they operate in, and how the results relate to product development theory. The summarised data from each case is shown in section 4.6.2, and discussion resulting from this analysis is offered in section 4.7.

4.4 Research Themes

The eight enterprises that were investigated shared definite areas of practice, seen as an overlap in methodologies. Considering that these results came from companies with a diverse range of products and also differing entrepreneurial backgrounds, this is an encouraging sign that the practices identified do indeed represent solutions to challenges that such businesses find in common. However, the range of activities described overall was seen to draw from quite a wide portion of the product development space, such that there were some aspects noted by only one or two entrepreneurs. It should be noted once again that as the respondents were sourced via their business incubator participation there is the likelihood that they were all offered similar tools, and this may contribute to the commonality. But as previously asserted, the incubators merely give access to a broader selection of solutions. The responses given by the entrepreneurs are their reflections based on experiences with many techniques, and they are in the position to objectively comment and identify the more important ones. The offerings of each entrepreneur were given without knowledge of others responses, thus any endorsement is unprompted and bolstered by first-hand experience.

The research questions sought to identify the NPD elements that were important, but also "where a difference between the attitude of importance and actual adoption occurred" (Beven, 2007). This is a key point, as in several instances there were practices identified by the respondents that are commonly thought to be necessary or effective, but were not actually implemented. Comments were made on several separate occasions to the effect of "I know this aspect is supposed to be important, but I didn't actually do that." Actual adoption and implementation is a powerful form of endorsement, especially when the experience is positively reviewed after the fact. Thus the practices that were actually implemented by the

start-up enterprises and then affirmed as being beneficial were obviously seen as the most highly recommendable.

There were several themes that occurred most prominently and were exposed by the iterative summarisation of the interviews. The great volume of raw data was reduced in order to display the most pertinent aspects and high level concepts of the subject area.

The major themes that emerged from cross-case analysis of the data are displayed in Table 1:

- ***Addressing the needs of the market, Market Validation***
- ***Involvement of technical experts, Mentors and Collaboration***
- ***Iterative development***
- ***Flexibility of product development process, project definition***
- ***Prototyping, model making, visual and physical representations, design communication***
- ***Minimum viable product***

Table 1 Major Emergent themes

The themes shown are topics that were most prominent, the areas of discussion that were referred to most often, and generated the most discussion. However, within these subject areas there was some distribution of opinions, perspectives on each being put forward and not necessarily resulting in agreement.

Minor themes were also present, being those topics captured in the data that were less represented but still deemed to be of notable concern to enterprises in their product development activities.

The raw data was also fed into Leximancer text data-mining software, and a cross-case analysis performed. The output is displayed in Fig. 4.

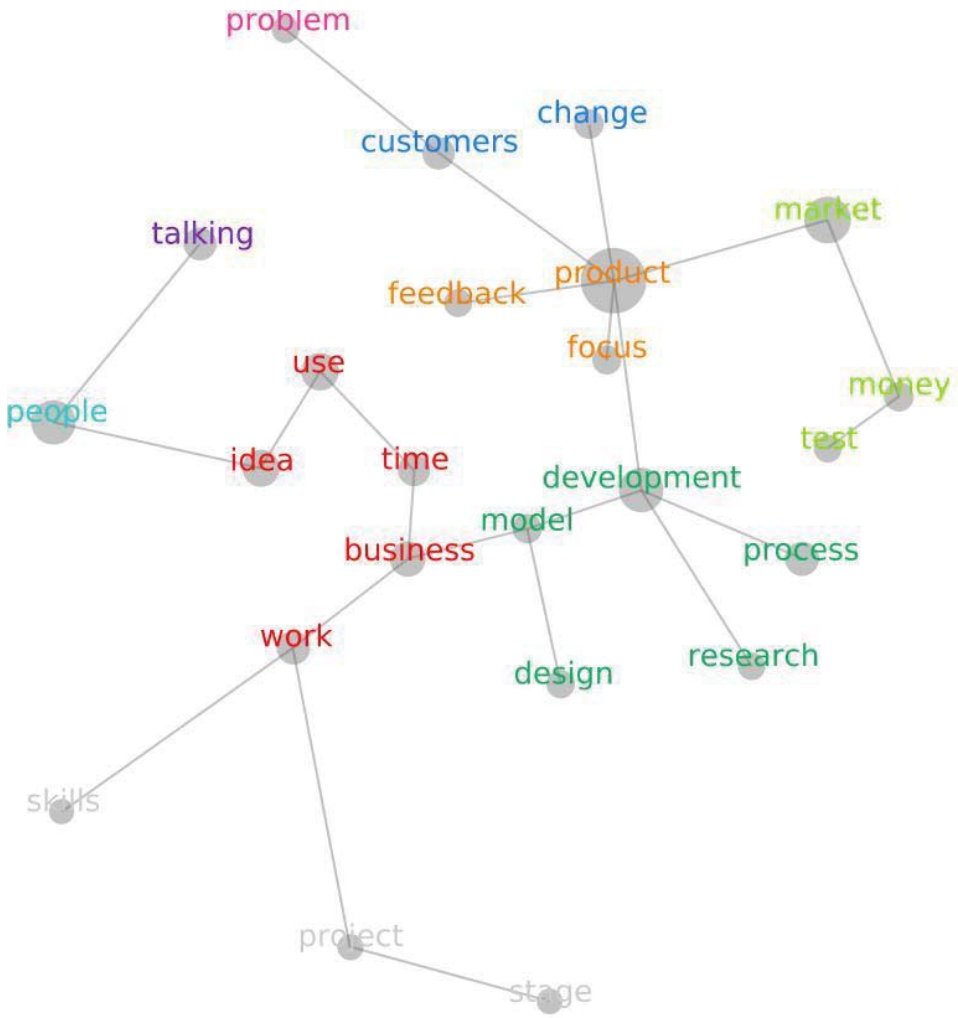

Figure 4 Cross Case Themes generated by analysis software

The findings go some way to support the major themes that were identified. The most prominent features are seen to be *Product* and *Development*, with *Market*, and *People* close behind. The size of the dot behind the theme represents importance, but all the number of connections must be taken into account. These themes are large, well connected, or both, signalling their prominence in the textual data. The product is closely linked with *Feedback*, also *Customers* and *Market,* which directly supports the market validation aspects that were manually extracted from the data. *People, Talking*, *Idea* and *Use* form a branch of the tree, therefore feed through each other, and follow on to themes such as *Business, Model* and *Development.* This is seen to support the discussion on collaboration. Mentors and technical experts, and the effect they have on pushing development speed and adding capability to the business.

Whilst this diagram is a visual method of linking the themes together, the major contribution the software made to the data codification process was through extraction and collation of

quotes from the large quantity of text. Quotes from the entrepreneurs are extensively used in this report (Section 4.5.2) as they convey the intentions and perspective of the speaker, clearly indicating sentiment. The software was invaluable in faithfully finding and matching comments across all the interviews, revealing the prevalence with which respondents were referring to similar topics. These comments were then able to be evaluated for their true sentiment and meaning.

4.5 Discussion

4.5.1 Introduction

This section offers exploration of the themes that were identified during analysis, through comparison of the views of each respondent and relating the findings to product development theory as presented in the literature review. The key comments from each enterprise are grouped together with the themes to which they relate, to allow the views of each respondent to be clearly connected and contrasted on each issue. The research questions that were initially posed are used to centre the discussion.

Whilst three distinct research questions are raised, discussion necessitates the merging of explanations somewhat. The identified themes have elements that pertain to each of the research questions; an NPD "best practice" will deal with critical success factors for the project, and there will be enablers and barriers that in turn assert their influence over these. Therefore, indication of the specific research question that is being addressed is offered where possible, but concurrent discussion is also used to ensure coherence of explanation.

4.5.2 Discussion of Major Research Themes

Addressing the needs of the market, Market Validation

One of the most prominent themes identified, this topic was very clearly visible and also represented the strongest area of agreement between the respondents. In addition, several of the other major themes identified (Table 1) are closely linked to this. Having a product that meets the needs of the market was identified as paramount, yet there are several ways in which this can occur, or approaches that can be taken to achieve this. All of the respondents discussed their method by which they sought to achieve this goal, and a variety of approaches were noted.

Enterprise	KEY COMMENTS THEME: *Addressing the needs of the market, Market Validation*
A	*Learning who your customers are and what their problems are. Fit a solution to what they need, solve the problem for the correct people. Find the ones that are willing to pay for it.* *Focusing on persona analysis. Not just demographics, but what really drives them. The main thing is whether people would actually go and use it. Talking to people, questioning your own assumptions. The core product is still there, but a lot of features have changed, and changed the target market. Market decreased but potentially can make more money from a smaller group, as the product is more targeted and therefore higher value. Find a market that is asking for a solution or something better, even if it is not explicit. Started with an idea, then looked at the market, refined or changed the idea from what was learned from potential customers, what they really needed.*
B	*Product offering changed the most from talking to customers. Get the market to express latent needs, then select the market whose needs are best met. Adjust the product offering into a form that was financially accessible to the correct market. Talk to customers and try to understand the problem before trying to solve the problem. The quality of the product was enhanced by talking to the market, and their responses dictated the features and specifications of the product.*
C	*What problem are you trying to solve for your customer, they are only going to pay for it if it solves a problem. So we pared back everything and we have just focused on one thing. That one question focused my mind on a new area and a much more productive area. Talked to real people, asked them how they currently do their business, why they do it that way and do they see any benefit in doing it another way. We found that some markets are just not appropriate. We would just spend too much time, effort and money trying to educate them or train them into certain way of thinking. Get a more narrow target market and work with a smaller bunch of people, but more successfully.*
D	*Think hard just about what we were trying to do and the product, whether there genuinely was a market for it not just that we thought there was a market for it. The best value for money was understanding social media marketing, interacting with my audience. Identifying compelling needs is really important. I was challenged to look at*

	the other side of the market, which was actually the side that will ultimately make me money. A unique superior product is very important, but it just has to be unique or superior in its own niche. Provided you identify a niche market and you create the niche market for your product and you market into that, then there is a plenty of room in the world for products that are similar but serve a slightly different need. It is important to involve potential customers in the development process or you won't have a market when you launch. Screening the validity of your product concept very clearly prior to committing is really important. If you haven't clarified that then you end up with a product that is maybe not meeting the market, just slightly missing it, and that's expensive when you have to get back and unpick the technology you have developed. If you know there is a market for you out there, you know the compelling problem and are really clear about how you are fixing it, then you can go and develop your product and you hopefully won't waste too much money.
E	*A key thing has been getting out into the market, As an engineer it's easy to get stuck just doing more development or adding one more feature, or fixing up this little bug - there are an infinite number of things that could be done. Critical to change that focus and figure out how do to actually sell this, persuade people to actually buy it. So marketing has been the biggest impact on actually getting it made. Get a better perspective on what the market actually wants and how does the product fit into that. Greatest effect on product offering was from talking to customers, getting some feedback. The market is very fragmented, diverse with different customer needs. The problem is putting out this product to all of them and maybe not really meeting the needs of any of them fully. Try and segment the market to address each one more specifically. Focus on markets that are easiest to get into.*
F	*Come up with a model and then make the product fit that quickly as opposed to going through a formal process and then trying to make the business to fit the product. Focus on the consumer first and then do the product development. Elicit genuine answers, the right answers. Try not to sell the product to them in the first instance, get them to tell you what it should look like. The best value was actually going out there and talking to people, a focus group with a whole bunch of product users. Then talking to professionals, tutors and designers. It is easier to focus on a niche market then expand from there, rather than trying to please everyone at the same time. Shift focus, see which market is going to take and grow the most. Consumer opinion was the main impetus for change, but also thinking about growth. A product at an early*

	stage has a lot of potential to change, so talk to customers before the product is too far down the track. Analysing personas, knowing exactly how the customers would think and behave, being able to solve the problems from their point of view. The product doesn't have to be unique or superior. It doesn't need to be the best thing everywhere, it just needs to solve the specific problems of the niche.
G	*Reason most small orgs fail is too much emotion involved, belief that their product is "the greatest thing on earth" without justification as to why. Need good answer to the fundamental question "what is this products place in the world?" The market and marketer should be driving the brief of the product designer. What the need is in the market should always be a start point. Need to analyse whether the market is interested, how much it is willing to pay, how much is the product going to cost, and cross check these all the time. Differentiate product development and product offering, PD is more about getting skilled people, and product offering is more about market aspect, what are you offering, to who, and why.*
H	*Some spatial design changes were made, and these changes were driven by brain-storming on relating the design to its function. Early adopters giving user feed-back were the drivers of refinement of the products functionality. The main market focus has shifted, but boundaries expanded as well. However, design specification was primarily to suit the focal market. Target market did change, as it proved easier to create new demand for the product in other areas rather than convert existing users of older technology. Existing users were quite set in their ways/methodologies, so introducing a more convenient technology was not as easy as expected. This "disruptive technology" also disrupted their entrenched practices. Market testing/market research was the main method in which the target market was established. First early adopters we utilised to give feedback, then begin to learn the market and get a feel for who will want the products benefits. People buy things because of a pain, an itch, or a fancy. If they have a pain it is easiest to sell to them.*

There are two extremes between which each approach can be seen to lie; tailoring a product to suit a particular market, or varying the market that is targeted to suit the particular product. These polarised approaches arrive at the same goal - that of a well matched customer and product. None of the entrepreneurs claimed adherence to only one method exclusively, there being elements of both used to varying degrees.

Where the inspiration for a product comes from is perhaps a “chicken or egg” debate. Does a technology push create a new need in a market, or was the capacity for desire always there and simply brought into focus by the introduction of a new concept? It could be argued that the “flash of brilliance” in which a concept is formed is triggered by something the inventor has observed, whether they are aware of it or not. Although concept generation in not addressed in this study (see Section 1.5), it is the starting point for the approach that an enterprise takes to market validation. If a strong concept for a product has already been formed before the market needs are evaluated, there may be more emphasis on finding the correct market for the product. When the concept is vague, it may be more important to approach from the point of view of evaluating the market and designing to suit.

Of the enterprises surveyed, it should be noted that none of them truly started with a clean slate in terms of product concept. All of the entrepreneurs had some semblance of a concept before they actively began testing the market, which broadly speaking means that they are all attempting to *“find the products place in the world”* (Enterprise A). This is an important concept because it is the nature of the product or idea itself which dictates whether a market will be sought for it or whether modifications will be made to bring it in to line with the market needs. For example, Enterprise F is involved with a product which was relatively inflexible in its ability to be modified. The product performs a very specific task, therefore the challenge was directed more at finding the right market to aim at. Enterprise C had already attempted the release of a product, but only after the realisation that the product did not really meet the markets needs was redevelopment undertaken. Enterprise D had an interesting combination of both. Through the use of social media it was found that a different dimension to the product was in fact more valuable to the initially identified market, then after further work it was found that the other side of the market would actually be where most interest would lie. An initially unseen opportunity provoked the change to a market that was previously discounted.

Whilst all the respondents reported changing their target market in some way over the course of the NPD process, the manner of the shift was not the same in each case. There are three general ways in which a target market is changed – the can be expansion of the market, contraction, or a shift in focus. Of course, the focus can shift in addition to the size being either increased or decreased, they are not mutually exclusive. None of the enterprises reported definitively *increasing* their target market significantly. All performed reductions in their target, shifted focus, and often elements of both. Enterprise H *“expanded the boundaries”* of their market, but this was more a case of noting that there may be others interested in their product rather than specifically targeting them. Their design focus was primarily on a smaller

group, and creating demand that may eventually grow into a larger market. What is telling is that the entrepreneurs approach in the first instance was to aim for a product that would appeal to the most people possible. This appears to be a commonly held belief, that the way to maximise sales is to aim the product at as many customers as possible. In theory, having a product which is desired by huge populations is the goal, but reality is that few products can span such a diverse range of desires.

The alternative, and one of the most strongly supported concepts across the surveyed enterprises, is the idea of meeting the needs of one specific market only. All of the entrepreneurs emphatically agreed that a product should meet the needs of one particular group as entirely as possible. Several went on to explain that this ideal should be adhered to even if it meant drastically *decreasing* the number of people that would be willing to buy the product. The argument made by Enterprise E was *"the problem is putting out this product to all of them and maybe not really meeting the needs of any of them fully"*, echoed by Enterprise C *"work with a smaller bunch of people, but more successfully"* and Enterprise F *"It doesn't need to be the best thing everywhere".*

Whilst it may appear that potential sales are decreased under this methodology, there are benefits that more than offset. One reason for this is that the business *"potentially can make more money from a smaller group, as the product is more targeted and therefore higher value"* (Enterprise A). Another is the potential expansion from that initial market. When a product is highly successful in its niche there are will be a knock-on effect, as a highly valued product will recruit others as unofficial salespeople. What was initially small market may grow into a larger one. This is the advice of Enterprise F: *"focus on a niche market then expand from there… see which market is going to take and grow the most"*.

Another benefit of correctly targeting a smaller market is that potentially a simpler product may be all that is needed. The "scattergun approach" comes to mind when observing classic attitudes to product development, where a multitude of features are included in an attempt to add value that may result in wider sales. The unfortunate outcome once again can be that the product does not satisfy any group properly. A product that is correctly targeted towards a small niche may do-away with all the extra features that added time and cost to a development project and can actually have a negative effect on the desirable features. Steady sales to a satisfied niche market resulting from a more cost effective design may be the formula for early return on investment, even if the returns are not of the magnitude that were dreamt about at the project's outset. These modest returns can be used to build on the early

success of the initial product, to then tactfully adapt the product and target other opportunities for growth. This methodical expansion ensures that the correct market is addressed by the products features at all times. And any new iterations or offshoots will be borne by the reputation built by the initial product.

With the strategy for target market selection in mind, there must be some way in which the correct customers are identified. A method of "persona analysis" was identified by those respondents familiar with Product Development terminology, and described by others in words such as *"finding out what really makes people tick"* (example from Enterprise G). The actual operational methods of carrying out a persona analysis were not explained in-depth by any of the respondents, other than mention of focus groups and having an understanding of the market through personal involvement or interest. However, it became clear than in some respects an entrepreneurial start-up can use similar techniques to larger organisations, the main barrier being resources.

Depth of personal experience can be considerable in one person, and a larger organisation may lack anyone with such valuable domain knowledge. Enterprise D suggested that the only time shortcuts can be taken when validating a market is when strong domain knowledge is held. However, it could be argued that personal preference may cloud a single person's ability to accurately pinpoint what others may desire, and the product offering could be misguided. Enterprise A expressly admitted this, as it was made clear when such assumptions were challenged.

Larger organisations may be able to procure market research data that is out of range of small start-ups. That said, gaining perspective on what the market wants can be a relatively low-cost affair if the time is taken to personally connect with the market. These costs are small in comparison to the money which can be wasted through misdirected development. It is clearly noted in product development literature that the costs of changing a product in the later stages of development are vastly greater than early re-directions (for example Verworn and Herstatt (1999). This concept was well understood by the respondents of this study, as evidenced by the comments of Enterprise F, *"A product at an early stage has a lot of potential to change, so talk to customers before the product is too far down the track"*, and Enterprise D, *"you end up with a product that is maybe not meeting the market, just slightly missing it, and that's expensive when you have to get back and unpick the technology you have developed"*.

These results marry closely with the sparse literature that exists on Market Validation as a recognised approach. Adams (2010) and Ries (2011), two recent exponents of this

methodology, make points that are echoed in the findings of this study. The area highlighted by the findings reported here is that start-up enterprises seem ideally suited to this approach. The literature suggests that benefits exist for all sizes of organisation, and this is likely, but the relative benefit for small start-ups appears to be greater. Without a greater body of knowledge on the subject to refer to this is merely a quizzical hypothesis, and no literature was found to provide clarification.

The final comment on market validation belongs to Enterprise G, who sums up the issues by saying *"the reason most small orgs fail is too much emotion involved, belief that their product is "the greatest thing on earth" without justification as to why"*

Involvement of technical experts, Mentors, and Collaboration

As this research was directed at enterprises of 3 or less people, it may be expected that there be considerable input sought from other parties. This was indeed found to be the case, but there are a variety of issues affecting the decisions that were made regarding the extent of involvement of outside entities, the consequences of this, and the factors that influence positive or negative results.

Enterprise	**KEY COMMENTS** **THEME:** ***Involvement of technical experts, Mentors and Collaboration***
A	*Incubator good source for professional networks.* *More resources would be useful after about the first 2 months. A bigger team would accelerate things.*
B	*A unique, superior product is good, but if you don't have the right people to implement it then it is worth nothing. Even a bad idea can maybe succeed with the right people. Core competency is not necessary, as long as you have the right people who do have those skills. Although being able to do all the work yourself means it is easier to realize your vision exactly, there are no communication issues. Someone developing for you might have a different vision to yours. Advice from mentors, industry experts. Vetting your ideas against professionals and getting feedback. Important to pitch your idea to people who have invested interest, they need to understand what you are doing. Tell them the basics about the product first. Investors want to hear the basics about what your product does in the first instance, not all the details. Mentors advice and potential customers most valuable. Having a person with*

	the correct skills willing to work for equity helps.
C	*Having technical skills would allow me to make changes on a whim, but because now I have to pay every dollar to make changes it forces me to think whether there is truly value in the change. Leveraging your core competencies is important, but I am also relying on other people's technical skills. Guidance with mentors, a different set of eyes looking at the problem, they have been through the problem before. I should have talked to experts or experienced people sooner. Anytime you speak to someone and think about your business and talk about your business out loud it helps. Networking is hugely important, to stop "reinventing the wheel".*
D	*I have an understanding of the product area and an understanding of producing something that will be appealing to the public, but my core competencies are not what is actually being used to make the product. I have to rely on other people's expertise to realize that vision. Creating it in my mind then passing that on to somebody who can actually make it happen. It is useful to have somebody to actually confirm that you are on the right track or on the wrong track or to give you contact with people. Developing a thing that is a huge part of the business with help from people around you. Access to people working in lots of different areas and many business connections. Professional networks – university departments, advice from professional friends, and friends who were in marketing also helped. I used a lot of people. That was a key part of my development.*
E	*Industry experts are involved. The main person involved is very good at following a brief, and coming back quickly with progress. To speed up development it was helpful to have a person who was very rapid in technical development. There is very clearly a very large dispersion in the abilities of individuals. Having structured networks in place to fill the gaps where your core competencies are lacking. Doing development in an area that is not core skills it would definitely slow you down. The whole rapid prototyping loop is slowed down. Better to have people who could focus on those areas that they are really good at. It is really helpful to have a group of people to talk to, mentors, rather than trying to make all your decisions on your own. As a sole-person start-up that's probably the biggest management issue.*
F	*It's hard when people are not motivated, but when you find people who care about it as much as you do, they have far more benefit to give. Core competencies, it's not necessary to leverage them. It is more about the process to make it happen. I thought the thing I had to learn was how to find a programmer wouldn't steal my idea. But*

	what I actually learned was about the process of getting something off the ground. And if you don't know that then you spend all your time on the technical stuff and not thinking about is the business scalable, is it repeatable, is it actually solving the need. So if you are too technical you won't be able to see the big picture. The structure is not so important, it is just good to have people around. If I had done this project on my own I wouldn't have gone out and talked to people, I probably would have just assumed that people would want the product. Having a team, you can quickly take a concept, fill it out and change directions in ways that you wouldn't think of on your own. Now if I have an idea I'll share it because it's less about the ownership of it, you have got to get over that, and just have access to everyone's opinions. Having mentors helped for motivation, if I was by myself, reporting to myself only I probably would only get around to when I felt like it.
G	*"Cross-pollination" – experience in one industry brings awareness that can carry over into another unrelated field. Have an open mind and be capable of research. Be able to quickly reach across a number of broad subjects, but leave the detail to the experts. Key is to be able to reach the experts, get them on-board. "Know what you know" and "Know what you don't know", but for what you don't know, get the best person you can. Research the best people in a field, and contact them. Talking to experts, you will very quickly cut to the chase, focus in on the key issue that you need to think about. If you try and do this on your own, you will spend too much time teaching yourself, getting distracted, going down wrong paths. Accelerate your education, and discard what is not going to be useful. Effective tool for filtering what is important. Involve several appropriate experts/necessary talent, sign non-disclosure agreements, and have a half-day workshop. You get much quicker development. Sometimes the expert will tell you that your idea will not work – listen to this advice, understand why they are telling you this and what the elements are that are incorrect, then change tack, modify your direction or make adjustments so that you are on the right track. Biggest waste of money is dealing with some consultants – consultants want to leave their mark on things, so will change designs that were not requested. Costly. People who try to make changes without seeking approval first. Invest time up front on recruiting and educating your team, getting the right people, articulate clearly what is required.*
H	*One difficulty was finding engineers with the expertise to design it. Talking to a professional Industrial Design company was important, getting input from initial*

	design through all stages. Led to winning of design awards. Finding local, qualified, highly skilled engineers who could design the product from scratch would have been valuable from the start. Difficult to find such people locally, as not many people have those skill-sets in this area. Proximity is important –outsourcing is good in theory, but having the right person close by to talk to is better. Lack of early funds meant that technical development was undertaken by students (low cost), but that meant that time for design was long, and in the end the result was not properly ready for production. More money at the start and engaging the proper experts at the beginning would have been better, as time to market has been slower than desired. Using experts that know how to design with the end production in mind – design for production, to meet compliance requirements, for minimal production costs. Structuring the business as a single person sub-contracting out certain aspects is a choice out of necessity, but also it makes sense as it minimises risk and costs of the whole thing. Having parts of the project fall within your core competencies is useful. In areas where you are less competent, get the top people you can to do their specialist jobs. In a larger organisational structure you have the people around you to draw on as a resource, so it is frustrating when you are on your own and people are not immediately available. Recognise where your core competencies are. A small boot-strapping start-up needs to follow a collaborative model. Professional services we paid for so as to avoid any of the issues that may arise from partnering, but in hind-sight it would have been better to recognise that a skilled engineer as a partner was needed from the beginning. This may have been a cheaper model to follow. Having structured input into the engineering process from market and sales people who know what they are talking about would have been valuable. This has been somewhat addressed by outside advisors and mentors. It is crucial for this input. As a single person start-up, there is the freedom to create something new, not like in a big company or in a more structured environment. It is unlikely that it could have happened any other way. Single people are good for initial creativity, then groups are good for process from then on. Mentors and advisors have been sought from day one and the whole way through. Support from the outside is very useful, from people who have "been there, done that". Networking is the best way for a single-person company to get things done.

The central issue surrounding the involvement of parties outside of the enterprise proper is the necessity for professional competencies to be available in the NPD process. Small start-up enterprises are most commonly *"built around a person or personality, the founder is major shareholder, decision maker, boss"* (Enterprise G). The founder commonly has some connection to the subject area of the product whether it be a personal interest or professional experience, but occasionally a concept is formed that is greatly removed from the developer's knowledge domain. Even if high level expertise is held in the subject area there is likely not to be sufficient strength in other matters. A product development project is more than just a technical challenge. Perhaps an experienced product developer may be skilled enough in all aspects, but the sheer volume of work that is ahead would see a single operator working on a lengthy timescale, for all but the simplest projects. From this it is clear that outside help will be a necessity for the majority of start-ups, and desirable for all others. As expressed by Enterprise H, *"A small boot-strapping start-up needs to follow a collaborative model"*. If it is accepted that the start-up will not be undertaking all works on its own, the issue then is brought to focus on what form that outside assistance will take, and how the input will be integrated into the NPD process.

All of the enterprises in this study had considerable involvement from outside parties, and a variety of different sources of assistance were noted. Simple contracting of services was an avenue taken by 6 of the companies, whilst two followed a model of profit sharing, or services for equity. A recurring comment of *"get the best help possible"* was voiced by all the respondents. Of course the operative word "possible" is different for each enterprise's circumstances; budget constraints may prevent expensive consultants from being enlisted, or access may be limited to some sources for various circumstantial reasons. Company G had difficulty finding electronics engineers with the correct sills who were also in close proximity, as was necessary for that particular development project. It was not initially possible to find anyone and the budget was tight, so the work was directed to students at the local university. Whilst the students performed some aspects adequately, there were definite issues with the timescale and work that resulted. Eventually the correct technical experts were sourced and excellent development progressed rapidly.

An entrepreneur possessing the high-level technical skills themselves may avoid that issue somewhat, and be able to press on with the technical development un-impeded. However, too much technical focus can actually be counter-productive. Enterprise C believes that having to rely on outside experts focussed the decision making process: *"Having technical skills would allow me to make changes on a whim, but because now I have to pay every dollar to make*

changes it forces me to think whether there is truly value in the change". Others such as Enterprises D and F were totally reliant on others to actually turn their concepts into reality. These entrepreneurs had strong domain knowledge in their product area, and technical skills in some aspects, but neither had any knowledge of how to write code for their software products. Thus it is clear that core competencies are not strictly required for technical development, and those enterprises that do possess the skills internally must still manage them efficiently. Enterprise G works on the model of all skills being bought-in, the main role of the entrepreneur being organisational. This can be extended to the extreme of the company founder acquiring a concept formed from others inspiration and domain knowledge, and bringing together the workers required to undertake the development.

Correct communication of design intent is an issue highlighted by Enterprise *B "Although being able to do all the work yourself means it is easier to realize your vision exactly, there are no communication issues. Someone developing for you might have a different vision to yours"* and Enterprise G *"consultants want to leave their mark on things, so will change designs that were not requested. Costly. People who try to make changes without seeking approval first"*. If the person recruited to do the work does indeed possess the correct skills to effectively complete the work, then the main issue that has to be addressed is the information that is passed between the two parties. The entrepreneur must be explicit in their request, and be clear what the boundaries of the design are. Referring back to the discussion on Market Validation, it is paramount that the final design meets the market need. Individuals may offer their own design flair or perspective on the issue, but this must be seen to truly hold value for the product offering.

Outside assistance need not be on a strictly services-for-a-fee basis, and there are many gradations between that and free advice at the other extreme. Enterprise B found benefit in having a skilled person working for equity, and Enterprise H recognises that a partnership from the outset would likely have been a better and cheaper model to follow. Collaborations can be formed under varying degrees of formality, which appears to be related to small size. Larger companies regularly form professional connections, formalised by contracts, key deliverables and project timelines. A small start-up can readily connect in an informal manner with contributors, such as previous work colleagues, friends, or other industry contacts. Enterprise H initially considered only professional services due to perceived issues associated with partnering, but then settled on a combination of both. Enterprise F began with similar assumptions, that any programmer brought on board was an intellectual property theft risk, but had a perspective change and expressed *"Now if I have an idea I'll share it because it's less*

about the ownership of it, you have got to get over that, and just have access to everyone's opinions".

Mentors and advice from industry professionals was another of the most strongly reinforced factors the respondents revealed. All of the companies surveyed had crucial input and guidance in the management aspects of the development. Enterprise E viewed making decisions without guidance as one of the biggest management issues that a start-up could face. People who have *"been there and done that"* (Enterprise H) or *"a different set of eyes looking at the problem, they have been through the problem before"* (Enterprise C) help to address a critical deficiency that is likely to be present in many start-ups. People can be technically skilled as just discussed, or have other desirable expertise such as in marketing or sales, but having an overall understanding of how each facet of the business and NPD process relate is something that a first-time entrepreneur may perhaps be lacking. Attention to the business as a whole rather than the product as a technical challenge was expressed by respondents, and mentors were seen as the best source for this type of guidance. As suggested by Enterprise G, the ideal entrepreneur would *"Be able to quickly reach across a number of broad subjects, but leave the detail to the experts"*.

Whilst the majority of the findings are directly reflected in the literature, the concerns of these entrepreneurs were not entirely as expected. Whilst intellectual property concerns were voiced by several of the respondents, that overwhelming impression was one of relief once collaboration was initiated or mentorship received. None of the entrepreneurs experienced any ill effects and all were quick to recommend that others follow suit. The necessity of outside help for start-ups is where the greatest affirmation to the literature occurred.

Iterative development

This concept has much overlap with the material covered whilst discussing Market Validation and meeting the needs of the market, yet it is more the operational method of achieving this end. A short section has therefore been dedicated to this process, as it was expressed that it is one of the critical methodologies of achieving a well-targeted product offering.

Enterprise	**KEY COMMENTS** **THEME:** ***Iterative development***
A	*Take another look at the product, more detail, then modify the product from what was learned, then repeat.*

B	*Keep presenting your progress to check that you are on the right track. It is easy to head down the wrong path if you don't keep reviewing what you are doing.*
C	*Planning the process out, identify a problem, get a minimum viable product, then trial it, then review it, trial it, review it. Figuring out the problem, just going in this repeating cycle of seek feedback, give them something new, seek their feedback. In one way we do it sequentially so we can test and refine, test and refine. When I meet with someone I may as well ask all the questions at the same time – so in some ways it is in parallel.*
D	*We started to develop the product, we assessed all the information we we'd gathered and put the product offering together. Then there's feedback coming in off that which we will assess and that will be informing of next phase.*
E	*The benefit I have found is having a development loop and then extending that development loop into the market, showing new features and getting feedback, and trying to incorporate actually what the market wants. What kind of features in the existing product do they use or really need, which give them the most benefit. The new list of proposed features will feed into the next stage of the development. Agile product development, get something out there quickly, get feedback and iterating that process to get to the point where you have what the market actually wants.*
G	*Validate your product first – value of the product must justify all the expense you are about to put into it. Then begin development, and quickly do mock-ups and re-validate with the market. Costs at the beginning are low. Make mistakes on paper, at the beginning. The evolution of a product is often about finding out what doesn't work, and understanding why, then introducing the improvement. Early learnings are always useful, even if not successful, as they will likely be able to be used at a later point. Up-front research will give its payback at some stage, maybe not straight away.*
H	*Went through an early "Proof of concept" phase, then first prototype, which was fully functional, but not in a complete form. Then field trials using different groups of early adopters. Based on those results, designed the final production unit. Final production unit went through two or three revisions, getting it working, redesigning for production and getting the costs down. The project did not have much wasted time/research avenues as financially it was a necessity to be careful the whole way. Major revisions have been made to some aspects, but it was necessary to go through the iterations at the earlier stages of the project in order to learn. "Do your*

	homework" and think through things clearly first, but then you have to start developing and use an iterative process to proceed. Lots of pre development work is only good to a point.

In essence, the iterative design process is checking that development efforts are indeed resulting in a product that meets the need of the market. This ties-in with previous comments regarding the costs associated with changing direction, and the possibility of the market shifting as will be discussed in the following section. If a project begins to wander away from the optimal solution, it is better to become aware of this sooner rather than later and adjust the focus to correct the trajectory. *"Financially it was a necessity to be careful the whole way"* (Enterprise H). Backtracking can be possible if misdirection is realised before it is too late and commitment has been made to one path. Even when the market has been very clearly confirmed and a product offering established, it is dangerous to assume that the correct product will surely eventuate. As warned by Enterprise B *"It is easy to head down the wrong path if you don't keep reviewing what you are doing".*

Specific investigation into iterative development methodologies was not undertaken during the literature review, but the concept surfaced in conjunction with other focus areas. It is a method that is used wherever uncertainty exists, as gathering information and revising is a method of honing in on the true goal. This therefore is another indicator of the lengths that these enterprises went to in order to ensure that their primary goals were achieved.

Flexibility of product development process, project definition

The small start-up enterprises that were investigated expressed that their product development activities were not strictly formalised, at least when their projects were viewed as a whole. However, there are definite methodical aspects to the process such that deliberate processes are recommended to be included where and when appropriate.

Enterprise	**KEY COMMENTS** **THEME:** ***Flexibility of product development process, project definition***
A	*Formalised process but flexible. Have an end goal in mind, but understand that the product and path taken will change so be flexible.*
B	*Structure to the business side of things, formal. To actually design and make the product is unstructured, informal. An entrepreneurial organization does not*

	necessarily need to have a lot of structure, but there must be a way of ensuring that important things are actually done. Things were done as they came along. Larger companies need structured decision making processes because there are many more people to organize. In a small company that kind of formality does not apply.
C	*Having a clear project definition is important, and a marketing plan. The problem is disciplining yourself, your time. Formality organises that, but can be restricting also.*
D	*formerly structured in that we went through a process of identifying audiences, target market, developing a persona of the ideal of customer and doing a business model canvas, so that we identify the various channels that we will be selling through and the various partnerships we would be forming. Anybody who goes into this process has got to be open to change. It's about the individual being willing to examine all of the assumptions they were and be willing to the change them if they discovered they were wrong. Having clear project is important once you start producing and developing because you have got to pass it on to other developers. Very clear definition of your product by the time you start developing is really important if you don't want to waste money. Organization and networking it needs to have a structure to it.*
E	*There was an overall plan but there wasn't any major structure or formality. There was sort of an ad-hoc formal/informal design process. We used an agile, rapid process. It can be a waste of time writing beautiful project plans with time-lines and development, and usually after a few weeks we are not doing quite that. I would have benefitted from some better organisational system or structure, trying to get more people involved in a structured way, more organised networks from the beginning.*
F	*Clear project definition is difficult because the project changes. If I had defined it right at the beginning, I wouldn't have been so willing to change it. Would make you inflexible, and may miss an opportunity because of being so focussed on one thing.*
G	*Multinational companies have very highly defined KPIs and CSFs. Formal inflexible process. Small start-ups have Informal, flexible NPD process. Most big organisations typically don't fail, but they don't take any risk. Tend to involve much more paperwork, be slower to make decision and therefore much less creative and innovative. Rare in large organisations for a culture to be created that allows people to take risks. Need to find the correct balance point between freedom to move and take risk, and not take risk so large as to risk collapse on failure. Include relevant checks and balances. Big difference between large and small companies is level of*

	procedural processes they have embedded in them – staff in large companies operate within controlled boundaries, as set from board-level down. Small companies have very different cultures, organisations build around a person or personality, the founder is major shareholder, decision maker, boss. Stronger guiding force with less checks and balances. Has strength, as people move quicker. A definite formula works well when you only operate in the same space/niche, but when you change, different industry, different size business, you have to maintain a degree of adaptability, be flexible. Have some principles/values, but be adaptable.
H	*Development has been structured in some ways – start with proof of concept, make sure whole idea would work, work out geometry and structure of device, how it ties in with the software. There are no formal decision making processes, decisions are made through gut-feeling and learning as you go. Formalised processes could have helped on the business side of things, sales and marketing, learning the market, as this was not a core competency of the entrepreneur. It was done this way out of financial necessity. Clear project definition is important. Tasks and milestones are necessary in order to drive the project and keep it on schedule. Whilst the project has not been formally structured overall, there was need to have a plan in place for each stage. Project plans were made where necessary, such as when delegating work to outside parties. Delivery dates and requirements must be set. Development processes should be done in parallel as much as you can, but both sequential and parallel processes are necessary due to the nature of the development project. Have definite decision gates and times where things sync together, which dictates linear sequential processes in some parts. Review of previous stages is important before moving on to subsequent stages. At the start of the project, need to define the best points where stage gate decisions should be made. Every product is going to be different, so you need to work out what is important in this project and that will dictate where you need to make feasibility decisions. A combination of defining what the decision is, define a date, budget, and be as disciplined as possible.*

The overall impression that was given by the respondents was one of methodology being necessary and desirable, but that the organisation and application of the methodology was subservient to the needs of the specific product development challenge at hand. Whereas a larger company may have a standard approach to NPD and all products must be fed through the process, small start-ups seemed to value the ability to assess what the project requires and

design a framework that fitted their needs. Thus the process is in some respect contained and measured, but tailored to fit a unique set of problems.

The disparity between procedures in different size companies may actually be a restriction imposed on the larger companies only; smaller companies may in fact have a choice to operate under either model. *"Larger companies need structured decision making processes because there are many more people to organize. In a small company that kind of formality does not apply."* is observation offered by Enterprise B, but formality can be applied by the small enterprise if so desired. *"A definite formula works well when you only operate in the same space/niche"* (Company G), and some small enterprises are happy to exist like that. If a small business were undertaking an incremental improvement, then a formula may seem logical to apply. In that situation there is an existing product and market, so there are at least some points of reference to which a development plan can be aligned. Innovative new-to-the-world product development in a small start-up enterprise is dealing with as yet unknown product, an unestablished market, and being performed by a company with no history or procedural legacy so it seems logical not to apply a generic formula to the problem.

The ability to change direction as and when required showed through clearly in the interview data. Observations of the project direction changing throughout the development process were voiced by several respondents, and most attributed to the need to match the product to the market. As more information is gained about an opportunity or a niche, the requirements of the development may change, perhaps suddenly. A rigid, pre-determined approach *"would make you inflexible, and may miss an opportunity because of being so focussed on one thing"* (Enterprise F).Enterprise G suggests that it is essential to *"maintain a degree of adaptability, be flexible. Have some principles/values, but be adaptable."* Enterprise D appeared to be a supporter of formalisation, but after probing it was established that the emphasis was to be placed on *organisation*, and that adaptability and acceptance of change is essential. The organisational aspect is to give some direction to whatever activity is being undertaken, but being able to re-organise and re-direct efforts when required. Formality need not mean rigidity. If meeting the market need is a primary success factor for NPD, and it appears from this research that it is, then there should be provision in any development methodology for adapting however is required to achieve that result. *"Have an end goal in mind, but understand that the product and path taken will change so be flexible"* (Enterprise A).

Clear project definition was cited as valuable by enterprises C, D and H, but refuted by Enterprise E and F. There was some agreement between C and F that defining a project can

end up being restrictive, however. The reason Enterprise D valued project definition was the need to give clear direction to other parties, such as technical experts. If there is vagueness supplied, then there greater chance that the work produced will not actually be what is required. This was echoed by Enterprise H – *"Project plans were made where necessary, such as when delegating work to outside parties. Delivery dates and requirements must be set."* It seems a balance needs to be struck between stiff procedure and counter-productive disorganisation.

Where true formality is beneficial to start-up enterprises is in the operational aspects of running a business. Budgets, accounts, contracts, IP protection and other well understood features of operating in a corporate world are ideal candidates for application of "best practice" theory. The fuzzy-front-end of product development is not the only challenge facing entrepreneurs, and established methodologies can greatly assist in business management.

The literature generally confirms that smaller firms follow informal pathways, and this was somewhat true in the enterprises observed. However the reaction to formalisation in this study was varied, some voiced opinions being different to the practices that actually took place. It is interesting to note that there was indication that formalisation does have its place, but the great variety of areas that the respondents said it could be useful means there was no real consensus.

Prototyping, model making, visual and physical representations, design communication

Whilst the majority of the themes identified concern management approaches there was also strong discussion around the area of design communication, which has operational and managerial aspects.

Enterprise	**KEY COMMENTS** **THEME: *Prototyping, model making, visual and physical Representations, design communication***
A	*Test the basic solution first before moving on to more complicated ones. Biggest review point was before the push to finish the prototype. That resulted in the scaling back of the product to something more manageable.*
B	*Spend more time making a physical product, model, prototype you can show people and let them use it then give feedback.*
C	*People when they are in a theoretical view of things are more likely to say it is good.*

	Then you give them something and say "look, that's the price" and they are not so positive.
E	*Go through some pre-prototyping market validation, initial models to get feedback from potential customers. If you have a lot of domain knowledge, or some justification then you probably don't need to do as much pre-development work. You may get a lot of positive feedback, but until you actually have a prototype that people can actually play around with and see how easy it is to work the product might not be actually what people want. You may also find that your product is not practically possible, even though the idea is good.*
F	*Prototyping, then getting it quickly to a stage when you can test it and then move it on to a finished product. Either focus on customer research, or if the idea is an experimental one go and do it straight away and get it out there. Learn which method works best for each idea, different concepts require different approaches.*
G	*Make quick and basic initial models in the first instance, very cheap and useful. Do this before paying expensive designers who might head down the wrong path for a while. Invest in the visual aspects – CAD. Images, show them to people as a communication tool, 3D printing. Communicates design quickly. Need to get good people, the right people, to buy- in to your vision, and add their energy to the project.*
H	*It is important to have something to show for market research purposes so you can get proper feedback, such as a prototype or model.*

In order to address the needs of the market, much emphasis was placed on actual contact with prospective customers themselves and methods of truly finding out what the customers want. Early adopters and product trials were therefore touted as a powerful source of feedback. The feedback that is received is expected to come close to that which would occur had the product been released full scale in that state of completeness. Genuine users trialling an actual physical product is as close a simulation to the real world situation as can be hoped. The responses are hopefully received in a form which can be directly used to improve the product, whereas in an actual market launch the "response" may simply be low sales and product failure.

The use of physical representations of the product appears to be the preferred method of bringing a design project back into the real world, and bridging the gap between the conceptualisations of designers and the evaluation requirements of consumers. It is valuable to have a hard-and-fast activity that needs to be a feature of a product development project,

which gives some understanding of why larger enterprises formalise their methodologies. Prototyping appears to be a valued activity, as design communication is particularly strong for technology based products that have some physical function, but also as it goes a long way towards proving the technology is viable and the project feasible.

Design communication is valuable not only to elicit market feedback, but also to promote buy-in from collaborating parties and align their focus to the design requirements of the product. *"Need to get good people, the right people, to buy- in to your vision, and add their energy to the project"* asserted Enterprise G, and continued to explain that when technical experts are presented a clear picture of the problem they are often remarkably quick to establish feasibility and offer solutions.

Minimum viable product

The concept of bringing a minimum product (MVP) to market is one that is likely difficult for perfectionist entrepreneurs to swallow. A trait of entrepreneurs is to be very enthusiastic about their concept, and there is the commonly voiced mantra of "making a world-beating product" or "the best idea in the world". When the reality of the business environment is included into the equation, with speed to market being critical and targeted products being paramount as previously discussed, releasing the all-conquering product begins to be less feasible. The entrepreneur has to make a decision as to when the product is "good enough" for the market, even if it is not good enough for their own personal dream.

Enterprise	**KEY COMMENTS** **THEME: *Minimum viable product***
A	*More features do not make a product more valuable. Narrow the focus and design a product that solves a pain-point for customers. Focussing on something that is very simple that solves one problem and solves it well. Get it to the market, that will give you an idea of whether it will work or not. Then continue developing from there.*
B	*Find the product solution that is easiest to get the minimum viable product.*
C	*We have spent a lot on things for the product that weren't necessary. The product was okay in lots of areas, but now we are trying to be really good in only one.*
D	*The minimum viable product had to be really quite refined and it wasn't just something to get in the market straight away. It had to be solid. Getting to the point of finding my MVP was extremely difficult, actually getting people to understand*

	what my product was, defining my product.
E	*Get your MVP out into the market, even it is really basic, simple, hardly does anything, at least people can start using it then you're getting feedback from people actually using the product. A lot more valuable than just talking to people.*
F	*The minimum viable product is the most important thing, getting something that the customer will be happy with, and getting that in front of the customer, and then working off that. Grab only exactly what you need and make it work. Having a MVP as a goal, small enough that you achieve it and test it quickly. Rather than developing everything and realising you have to go back to the beginning. Set-based design, design several things and bring them all through, rather than going to the end of one and finding it's not right.*
G	*Incremental improvements can always be found, but you have to find the balance point where you stop making changes and put the product out.*
H	*Development has been a lot more complicated than some people initially said – more difficult than simply quickly getting people to design some electronics and cheaply manufacturing in China. The project did not have much wasted time/research avenues as financially it was a necessity to be careful the whole way. Time for design was long, and in the end the result was not properly ready for production.*

The operative word in this theme is "viable". That means that the product is most definitely not a sub-standard offering, it must be a robust product that will not disappoint the market - the need of the market must be sufficiently satisfied in order for the product to be a success. The minimum viable product is a "slimmed down" version of the grand design, one that is easier to develop.

All of the enterprises reported having to cut their development short of their initial conceptualisation. For several this was a conscious decision at the outset of the project, that the goal would be a simplified yet solid product developed with the minimum time and cost. For others it was a realisation that was arrived at once development began to drag on, and the list of features of the product began to grow, or slight adjustments kept being made with no real justification attached. Incremental improvements can always be found, but you have to find the balance point where you stop making changes and put the product out" reflected Company G, and Company C *"We have spent a lot on things for the product that weren't necessary"*.

There is a blurring between the minimum viable product and prototyping, in some cases the simplified product was a well put-together test item. Of course, this is straying from the ideal of the robust offering that will not damage the reputation of the product. As Enterprise E explained*, "get your MVP out into the market, even it is really basic, simple, hardly does anything, at least people can start using it then you're getting feedback from people actually using the product. A lot more valuable than just talking to people"*. There seems to be a shift away from the launch of a fully-fledged product marking the end of the project, to an expectation that the product will be requiring further development. The old mentality is noted by Adams (2010, p. 24) as "an overwhelming tendency to see the product development process as over once the product ships". He offers a strong argument that reducing the number of features and dominating a smaller market is a realistic strategy for gaining the traction that is required to expand to other markets.

In some ways this is a form of staged-delivery, where some features are held back to later models in order to sell the slightly more improved version to the same customers who already enjoyed the first iteration. But primarily it is about setting an achievable target for the NPD project, as expressed by Enterprise F: *"Grab only exactly what you need and make it work. Having a MVP as a goal, small enough that you achieve it and test it quickly*". This can be approached from a slightly different perspective such as the approach by Enterprise B: *"Find the product solution that is easiest to get the minimum viable product".* Here the actual concept is screened to find one that is more achievable, and the selected candidate will itself be developed in its simplest viable form.

There are difficulties achieving the minimum viable product, however. Of highest importance is properly defining what the MVP truly is. This relates back to market validation, identifying as clearly as possible what the market needs, and the minimum form this must take to satisfy. This was the case for Enterprise D: *"The minimum viable product had to be really quite refined and it wasn't just something to get in the market straight away. It had to be solid. Getting to the point of finding my MVP was extremely difficult, actually getting people to understand what my product was, defining my product".* Enterprise H encountered challenges in bringing the product to market, but these were connected with inaccurate estimations of the development time. What was initially expected for the project did not eventuate, and the time to market increased greatly. In the end the product was slimmed down out of necessity, so the result was in fact the minimum viable product. This brings a second pertinent point, that once the scope of the minimum viable product is established, only then can a true estimation of the project cost and time scale be made. For some products the MVP may represent a relatively

small proportion of the full-featured concept, and for others it may be the majority. By establishing the MVP the areas of the project where value can truly be added are identified.

5. Conclusions and Implications

5.1 Introduction

This thesis presents the idea that early-stage product development in small start-up technology-based firms does not generally follow a rigid, formal methodology, and the adoption and adaption of different techniques varies depending upon circumstances. This is in contrast to the development activities often employed in larger, established firms where an NPD "formula" can be applied in a pre-ordained, formalised manner. The argument is made that product development in the new start-up context is more an exercise in adaptive project management than methodology application. However, there are elements present in the early-stage product development activities of start-up enterprises that are also seen as integral to formalised methodologies. There are shared techniques between the two, but it appears that the organisation and implementation of these common traits is an area of difference.

Factors critical to success have been identified, and are viewed from a high level perspective so that the concepts being put forward are applicable to start-up enterprises as a group rather than being specific to the context of individual companies only. Barriers to product development success are also outlined, and found to be more than simply the absence of the critical success factors.

5.2 Conclusions

5.2.1 Introduction

From a theoretical point of view, small start-ups perform many of the same tasks as other bodies undertaking development. From an operational point of view there are pronounced differences.

Relevance to the intended market appears as a primary driver of the product development process, the resulting product meeting the markets needs as fully as possible being the goal. In principle, the resulting product can be the same regardless of which entity undertakes development; an offering that meets the certain needs of a specific niche. It can be theorised that there must be constants within the development of a specific unique product that are required to occur in order for that particular permutation to be produced. An interesting example of this is the information that was gathered to guide design.

A specific product has issues that were addressed in order for the development to proceed to that end result, an identified need being the typical driver. Specific information was used to develop that product, and any different information would have resulted in a different solution being formed. When viewed like this, it can be seen that a company achieving that unique result required certain information to arrive at that conclusion. Any other company independently arriving at the same solution is likely to have encountered very similar information. The differences are found in the way in which the information concerned was elicited, or perhaps the form the data took. This is where NPD best practices are of concern: what is the best method of arriving at the ultimate goal, given that differing paths may be followed?

5.2.2 Conclusions about Research Question 1

From a wide angle perspective, small start-up enterprises do adopt practices in their early-stage NPD that are also utilised by larger companies. This can be rationalised somewhat by continuing with the previous analogy, that of a specific product resulting from development undertaken in two different hypothetical companies. In this example the goal for each company is the same, but there are also other aspects that are similar to each. Some product-specific challenges that are faced will be common, such as technical development, the engineering behind the physical product. The target market will need to be reached, and the valuable information gathered that guides the developers towards the successful design. There will also be the threat from competitor's products and the race to get the product to market. On the surface, there are many factors that are shared. To address these concerns, both companies must correctly identify an opportunity in the market, solve the technical challenges, and do so before the opportunity is missed.

But when the physical act of clearing these hurdles is dissected, it becomes apparent that the two paths are operationally quite different. The most prominent ways in which small start-up's NPD practices differ from the "best practice" methods observed in larger companies are:

- *Degree of formality*

Complexity in business structure leads large companies to develop formalised structures in order to organise the many contributors. Without a system, chaos may reign. Small start-ups have a vastly simpler organisational structure, and thus implementing a rigid formal process may not provide benefit. There are activities where a degree of formality is beneficial - when

procedure and protocol complement an activity, and implementation of these procedures is realistic for the enterprise.

Perhaps the most valuable observation is the effect that flexibility has on the ability to truly adapt the product development process as needed to achieve a well-targeted product. The trait of entrepreneurial start-ups being relatively free from rigidity pays dividends when the product development direction is an organic phenomenon. The natural and necessary flow of influence begins with the market which dictates the products design, which in turn reveals the development path, and finally the enterprise adapts itself to suit. There must be one part of the chain that is able to conform as required. Changing the design will affect market targeting, as could a different development path. The enterprise represents the part of the system that is most under the control of the entrepreneur, so it is here that the adaption should occur.

- *Involvement of technical experts, Mentors and Collaboration*

Collaborative models are becoming more common in product development, with companies of all sizes obtaining benefit from outside involvement. So in that respect, small start-up enterprises may be said to be line with industry practice. However, this aspect of the product development process is singled out in this research as being different where small enterprises are concerned. This is due to the scale on which collaborative involvement is utilised, and the impact it has on the NPD process in these companies. The phenomenon can be strongly linked to the size of the organisation; an entrepreneurial start-up is very likely to have more collaborators than actual employees. There is no great pool of staff knowledge amongst which the development can be delegated. The entrepreneur out of necessity must look to others to bolster capabilities.

This physical requirement brings with it extra value, however. The entrepreneur has the ability to “shop-around” for the appropriate experts for their particular development project, whereas an established organisation would tend to draw on their own staff. The combination of contributors selected can be tailored to the needs of the project, and adjusted as development proceeds. The individual knowledge domains of the chosen contributors afford a diverse mix with potential to trigger innovation. In a sense, an entrepreneur has the ability to design a business based around the needs of the product concept, once again following the theme of all things subservient to the market. Contrast this with a large established company, and you see a predetermined development team following a rigid development methodology. Even if the true market need is identified, the development environment may not be optimised to meet it.

The other major themes discussed in this research are commonly found in organisation of all sizes and structures. *Addressing the needs of the market*, *Iterative development* and developing the *Minimum viable product* are valuable concepts to all, but can have different implications for small business. The MVP relies on accurate identification of market need, and iterative development is used to ensure that they are both achieved. A small start-up enterprise may find market research demanding of resources, but the minimum viable product gives some achievability to the project. A small nimble organisation can rapidly work in a feedback loop and re-shuffle their business model as the project requires.

Prototyping is a standard fixture of NPD, and well understood for proof of concept and customer feedback application. The notable use that start-up technology based enterprises have for design communication activities is in their interactions with outside contributors. The technical experts, mentors or financial backers that form such a large part of a start-up's business model can be recruited into partnership, investment, or simply communicated with efficiently in this manner.

5.2.3 Conclusions about Research Question 2

Success in NPD can be measured and quantified in many different ways, but through the investigation undertaken in this research success is considered with respect to early-stage development activities. One definition of success in this context may be an entrepreneur obtaining accurate market validation of a product concept, and forming an appropriate business entity that allows optimal development to proceed. Critical success factors can take a physical form such as environmental influences, or even be theoretical and unquantifiable such as the attitude, drive and energy of a person. The factors may be required at the beginning of early-stage development, or emerge during different phases of the whole project. Of course there are a multitude of factors that must combine for a development project to proceed optimally, many of which may be simple yet essential. The factors identified in this study are therefore not a comprehensive list, but they are those that were deemed challenging enough to warrant in-depth discussion.

The first and most obvious critical success factor is that the product is validated with respect to a market. This overarching goal only becomes apparent after the development has proceeded somewhat, it is clearly not a physical factor that can be simply noted at the very beginning. It is, however, essential that this be established as early in the project as possible, and then maintained throughout the development. Without attention to this factor, the product that results may not be desirable to customers when the time comes to sell it.

Closely related to this is the concept of the minimum viable product. It is tied to market validation as the validation exercises reveal what it is that the customers value most, those features that must be included in order for there to be strong enough interest from a particular market segment. Another benefit of identifying the MVP is that the scale of the development project may potentially be reduced. Not all design concepts contain superfluous features but the ones that do can be trimmed down to a more manageable form, a boon for a small cash-constrained start-up looking to sprint to the market and achieve return on investment sooner.

A critical success factor that affects every stage of the development process is collaboration and input from sources from outside the company. A small start-up lacks the staff resources to have all the skills for the project in-house. They must look to others to supplement this. Mentors are especially beneficial, as they provide expertise and experience in the management of the product development project itself. Technical experts provide high level experience in the conceptual and physical development itself. These two forms of input can be procured in different ways such as partnering, equity sharing arrangements or consulting, but the key point is that the correct advisors and contributors are identified and brought on board.

5.2.4 Conclusions about Research Question 3

Inhibitors to product development in start-up technology based enterprises are understandably numerous. To undertake highly novel development with few resources, often little previous experience in NPD and with present-day competitive pressures is a daunting task. The inhibiting factors most notable in early-stage NPD are of course those that affect the presence or attainment of the critical success factors, and those that stand in the way of product development methodologies.

Access to outside expertise plays an important role; if it is difficult to establish connections the development will suffer. Reasons that access may be restricted can be due to proximity, whether geographical or cultural, and the ability to overcome the distances may not be present. Technology may allow long-distance collaboration for some projects, but others need face-to-face interaction. This is of particular concern for small enterprises in New Zealand and Australia, due to low population densities and geographic isolation in some cases. This is not to imply that there are not technical experts of high calibre in these labour pools, but simply that these small, spread-out populations are quite removed from the industrial centres of Europe, America and Asia. Where long distance collaboration is appropriate for the product being developed, geographic constraints are not as relevant. Once again, the demands of the

individual development project dictate the environment in which optimal conditions are found.

Design communication is required to establish buy-in from other parties, then facilitate productivity. The entrepreneurs own attitude to outside involvement may be a huge barrier to positive progress. If input from collaborators is not considered in a balanced objective fashion, then the advice is not effective. This attitude can also cause problems when achieving market orientation. It is a common trait for an inventor to have the belief that their product is “the best in the world”, and that everyone will want one. If the information from market validation efforts is not truly heeded, then change will not occur. It can be difficult for an inventor to accept that the concept they are so passionate about is not in fact the correct solution. The entrepreneur’s ability to challenge their own beliefs can be the major factor that allows a project to redirect to where the indicators lead.

The overall management perspective is perhaps the most critical factor in the projects development. The recognition of the entrepreneur that the product development project will require change and adaption throughout is an essential mindset. This allows flexibility in the process, positive input from outside expertise, and the best chance of proceeding down an optimal product development path.

5.3 Implications for theory and practice

The research carried out in this project was exploratory in nature, designed to expose current practices in New Product Development, and provoke discussion on these. The resulting study represents an addition to the body of knowledge in this particular focal area, an offering to incrementally improve understanding.

Whilst this study does not present data that can be scaled to a population, the information given here can be taken into consideration and assimilated into the decision making process if the managers of a small enterprise recognise parallels with their own project.

5.4 Limitations

The enterprises observed by this study are small technology-based start-ups, and their early-stage product development activities were the focus. Other forms of enterprise, and other stages of the process were not included, as described in Section 1.5, Definitions and Delimitations of scope.

A large quantity of raw data was collected through the interview process, however there is always the concern that deeper investigation would reveal further insight. The number of cases falls within accepted case study practice, but by the same token the degree of replication can only be claimed to a certain level, no more.

As described in Section 3.3.2, the respondents were all involved with business incubators to some degree, and justification for this selection has been offered. Whilst this focal decision benefits the study, it also must be acknowledged that that it limits some areas of the findings by unavoidably introducing some bias.

5.5 Further Research

This research project sought to explore early stage product development activities in start-up enterprises, with the aim of contributing to the body of knowledge in the subject area. Exploratory research seeks to expose rather than explain phenomena, and is directed towards building hypotheses and propositions rather than testing them. Research of this type is valuable, however, as it is an ideal precursor to such explanatory exercises where the driving factors behind the exhibited behaviour are studied.

In this study interviews were undertaken with a range of entrepreneurs from different backgrounds, involved in the development of products of varying nature. The scope of study was deliberately broad, in order to capture data from different regions of the product development space. This enables interesting observations to be made, but falls short of offering any rigorous confirmation that these practices and opinions are indeed commonly used, or whether there will actually be a positive effect on product development performance for any enterprise that may replicate these actions. These types of assertions must be made with the backing of an appropriate research methodology, such as an experiment or an empirical method of obtaining statistically significant results. Therefore, further research could be directed at strengthening the findings of this study, in order to confirm or discard the hypotheses that have been put forward. An even greater extension would be the observation of these further-refined principles being applied in future entrepreneurial endeavours. A longitudinal study may be the opportunity to link certain product development management practices to new product success.

This study investigated companies from both Australia and New Zealand, and the focus was on exposing the practices that they find most beneficial. However, the research did not allow for a true comparison of the differences between the two countries. Once again the study was not

directed at providing evidence that could fully support discussion on this topic. Product development in small enterprises appears to follow a much more “as-needed” path than larger companies, hence there can be differences between operations in contrasting environments. Whether there are distinct and consistent differences between Australian and New Zealand NPD practices needs to be established, then an investigation into the drivers behind any differences could be undertaken. A possible benefit from such a study could be as simple as exposing techniques that are used in one area that could be beneficial in another, or as complex as revealing the interaction between the environment a company operates in and the NPD approach that is required.

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